An Investigation into the Personal Carbon Dioxide Emissions

A cross sectional study of healthcare professionals in a teaching hospital

By

Ikumi Fushimi

The Bartlett School of Graduate Studies
University College London

A dissertation submitted in part fulfilment of
the Degree of Master of Science Built Environment:
Environmental Design and Engineering

University of London

September 2007

Acknowledgements

I would like to thank my tutor, Ben Croxford, for assistance he has given me writing this thesis.
I also would like to thank all healthcare professionals at Queens Medical Centre, Nottingham, who kindly took part in my questionnaire.

Abstract

The aim of this thesis was to investigate personal carbon dioxide (CO_2) emissions using a case study of 37 healthcare professionals. This study involved exploring a method of calculating personal CO_2 emissions in the 3 main spheres of household energy use, car travel and flights and profiling personal energy consumptions. Secondary objectives included the identification of potential areas of CO_2 emissions reduction and barriers that people face towards making these reductions.

A questionnaire was adopted as a method to collect data surrounding energy consumptions and to provide a framework for semi-structured interviews to obtain personal views and feedback from survey participants. This method proved to be a viable and reproducible approach to calculating visible domestic energy consumption; less visible sources of energy consumption such as work-related consumption was beyond the scope of the questionnaire, and thesis.

The combined annual CO_2 emissions from the cohort interviewed was 245 tonnes (approximately 6.6 tonnes per person) 37% of CO_2 emissions were due to household energy use, 36% from car travel and 27% from flights. There was marked variation in carbon emissions amongst the individuals interviewed. Such variation hints towards potential for carbon emissions reduction. Indeed, when interviewed, most individuals acknowledged that more could be done to reduce personal carbon emissions. However, when asked about obstacles towards reducing carbon emissions, the commonest answers cited a lack of governmental support, with other common answers citing inconvenience and an unwillingness to sacrifice or adopt a lifestyle change. The majority of those interviewed felt that climate change was real and at least partly contributed to by human activity. Potential legislation for reduction of carbon emissions was also discussed. Personal carbon trading appealed to most interviewees, followed by energy rationing. There was wide variation in what people thought was a fair tariff for a tonne of carbon dioxide emission.

Contents

Chapter 1: Introduction

1.1 Aims

The aim of this thesis is to investigate personal carbon dioxide (CO_2) emissions. A case study of 37 healthcare professionals based in Queens Medical Centre, Nottingham was undertaken to carry out this investigation. This study involved exploring a method of calculating personal CO_2 emissions and profiling personal energy consumptions. Secondary objectives include the identification of potential areas of CO_2 emissions reduction and barriers that people face towards making these reductions.

1.2 Rationale

"*We now face two immense challenges as a country – energy security and climate change*" [1]

There is a paucity of fossil fuels, which are concentrated in specific regions of the world notably Russia, Central Asia, the Middle East and Africa. This, coupled with a growing energy demand from rapidly developing countries such as India and China, has fuelled competition for reliable sources of energy. Although the UK has been self sufficient in oil and gas until relatively recently, it is becoming increasingly dependent on external energy sources. Energy, therefore is at a premium, and energy conservation is becoming increasingly relevant in this context. CO_2 emissions measurements provide a measure of fossil fuel consumption.

There is a growing body of evidence supporting the notion that human activity such as burning fossil fuels and deforestation at least in part, drives climate change. Burning fossil fuels produces "greenhouse gases", the foremost constituent of which is carbon dioxide. Such gases are thought to contribute to global warming through the "greenhouse effect".[2] The UK has committed to a goal of

[1] Foreword by Tony Blair in "The Energy Challenge". Energy Review Report 2006, Department of Trade and Industry

[2] Greenhouse effect: Greenhouse gases present in the atmosphere absorb outgoing infrared radiation from the earth surface (terrestrial radiation) causing heat retention. This greenhouse property of the atmosphere acts as a natural blanket over the earths surface, making it warmer than it would otherwise be. Without this effect the earth's surface would be 20 to 30°C colder and much less suitable for life. However, changing the greenhouse properties of the atmosphere will lead to changes in the earths radiative energy budget (the balance between incoming energy from the Sun and outgoing energy from the Earth), which leads to a global warming and as a consequence will affect other aspects of the Earth's climate. http://www.royalsoc.ac.uk/page.asp?id=1279

reducing CO_2 emissions by 60% by 2050. In the UK, over 40% of CO_2 emissions come from domestic energy use and personal travels. Therefore, a measure of personal CO_2 emissions is relevant to explore potential areas to reduce CO_2 emissions from individuals which can contribute to overall CO_2 reductions at the national level.

1.3 Methodology

An investigation into personal CO_2 emissions employs a method of estimating personal carbon dioxide emissions and compiling personal energy consumption. A number of on-line based CO_2 calculators including the government trial CO_2 calculator were consulted to identify a suitable method of calculating personal CO_2 emissions. A questionnaire was designed to collect data surrounding energy consumptions and to provide a framework for semi-structured interviews to obtain personal views and feedback from survey participants.

1.4 Outline

The structure of this thesis is outlined as follows. Chapter 2 reviews the existing government measures designed to reduce CO_2 emission from individuals. One of new proposals, personal carbon trading, is also reviewed. Chapter 3 reviews a method of calculating personal carbon dioxide emissions and its limitations. Chapter 4 discusses the design of a questionnaire to profile personal energy consumption data. Chapter 5 reviews CO_2 emissions associated with household energy use between different household types. Housing structures, heating systems, ownership of household appliances and the possible impact of these on household energy consumptions are analysed. The uptake rate of energy efficiency measures such as energy efficient light bulbs is also reviewed. Chapter 6 reviews CO_2 emissions from personal car travels and the impact of personal travel patterns such as commuting and food shopping. Chapter 7 reviews CO_2 emissions associated with flights. Chapter 8 reviews the survey responses on a number of environmental issues included in the questionnaire and review the individual's attitudes and propositions towards the environmental problem. Chapter 9 provides conclusion of the thesis.

Chapter 2: Individual contributions to CO_2 emissions

2.1 Background

Domestic energy consumption in the UK has been increasingly steadily since the 1970s due to a number factors including the increase in the number of population, the increase in the number of households, the wide spread of central heating installation among households and the growth in the ownership of household appliances.[3] Although the improved energy efficiency of household appliances has moderated the growth rate of household energy consumption, domestic energy consumption is expected to rise as more people are living alone (two people live alone use more energy than two people live together) and the number of electric appliances owned by households is expected to rise.[4]

Over 40% of carbon dioxide (CO_2) emissions in the UK are attributed to individuals from domestic energy consumption and personal travels.[5] For the average UK household, nearly three quarters of carbon dioxide emissions are due to space and water heating and one fifth from lighting and appliances.[6] Most people are unaware of how much CO_2 emissions are emitted as a result of their everyday activities and the choice they make on what kind of household appliances to buy and how to travel etc. Significant CO_2 reductions from domestic sector can be achieved by individuals taking actions to reduce CO_2 emissions through making simple changes in behaviour, making informed decisions when purchasing appliances and investing in adequate energy efficiency measures.

2.2 Definitions

Before proceeding with the investigation into personal carbon dioxide emissions, it is necessary to clarify what personal carbon dioxide emissions include. Many similar terms such as "carbon emissions" or "carbon footprint" are used to indicate carbon dioxide emissions associated with direct and indirect consumption of fossil fuels. Burning fossil fuels produces greenhouse gases such as carbon

[3] Energy consumption in the United Kingdom, Department of Trade and Industry (DTI), Available at http://www.dti.gov.uk/energy/statistics/publications/ecuk/page17658.html
[4] Social Trends, No 37 2007 edition, Office for National Statistics, Available at http://www.statistics.gov.uk/downloads/theme_social/Social_Trends37/Social_Trends_37.pdf
[5] Department of Environment, Food and Rural Affairs (DEFRA), http://www.defra.gov.uk/environment/statistics/globatmos/gagccukmeas.htm
[6] http://www.statistics.gov.uk/STATBASE/ssdataset.asp?vlnk=7287

dioxide. There is a growing body of evidence that links an increased atmospheric concentration level of greenhouse gases with global warming, suggesting that climate change is at least in part, man-made.[7] The UK ratified the Kyoto protocol and it has a number of goals to reduce CO_2 emissions including a 60% CO_2 emissions reduction by 2050.[8]

Personal CO_2 emissions consist of direct and indirect emissions. Direct CO_2 emissions include personal consumption of fossil fuels through the use of gas and electricity at home and fuels consumed in personal travel. Indirect CO_2 emissions are less obvious that they include those related to the consumption of goods and services. Construction of buildings and production of goods and services all involve energy in their processes including transportation, manufacturing, refrigeration, lighting etc.
The calculation of indirect CO_2 emissions is complicated and problematic, as the energy involved is usually less apparent to customers. Since CO_2 emissions associated with production and distribution of goods and service are accounted for by producers and service providers, this thesis focuses on the direct personal carbon dioxide emissions. This includes personal fossil fuel consumption such as gas and electricity and fuel for transport. The contents of direct CO_2 emissions and how to calculate them will be discussed in Chapter 3.

2.3 Framework

In order to reduce energy demand from the domestic sector, the government has implemented several measures to save energy through improved energy efficiency. The key measures include improving the energy efficiency standard of newly built homes, improving the thermal standard of the existing homes, improving the minimum energy efficiency standard of household appliances and raising the public's awareness of energy conservation.[9]

---

[7] Intergovernmental Panel of Climate Change (IPCC). http://ipcc-wg1.ucar.edu/index.html
[8] The Kyoto protocol: The Kyoto Protocol to the United Nations Framework Convention on Climate Change is an amendment to the international treaty on climate change, assigning mandatory emission limitations for the reduction of greenhouse gas emissions to the signatory. The objective of the protocol is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." As of December 2006, a total of 169 countries and other governmental entities have ratified the agreement (representing over 61.6% of emissions from Annex I countries) http://en.wikipedia.org/wiki/Kyoto_Protocol

[9] Meeting the Energy Challenge. A White Paper on Energy. May 2007. DTI

With regards to personal transport, the government has launched several campaigns at places of work and education, to promote more sustainable methods of commuting such as walking, cycling and using public transport. Increased fuel-levies are imposed on less fuel-efficient cars. New cars are now fitted with a mandatory CO_2 emissions label (expressed in CO_2 gram per km travelled) to aid customer choice.[10] Although a preliminary fuel tax on flights was initiated in February, more concrete steps towards limiting air-travel face political and commercial opposition.[11]

Despite the aforementioned measures, the government has as yet largely relied on the public to voluntarily reduce personal CO_2 emissions. There has been no legislation towards enforcing the national target of a 60% reduction in CO_2 emissions by 2050 in the domestic sphere. Although newly built homes are more energy efficient, they constitute 1-2% of the total housing stock in the UK. Government-sponsored initiatives toward improving energy efficiency in existing housing stock such as warm front scheme are primary targeted at more vulnerable sectors of population e.g. fuel poverty.[12] [13]

It has been argued by many critics that a new framework would be necessary to engage all individuals and households to act collectively to achieve CO_2 emissions reduction.[14] There are two possible approaches to establish such framework; taxation and energy rationing. Taxation is the most common and well known policy instrument. Many European countries adopt energy taxation to encourage individuals to conserve energy. This has been already implemented in the business sector known as the climate change levy to encourage organisations to improve energy efficiency through financial incentives and disincentives.[15] However, taxation is largely unpopular among the public and it is likely to cause resentment.

---

[10] Meeting the Energy Challenge. A White Paper on Energy. May 2007. DTI

[11] Meeting the Energy Challenge. A White Paper on Energy. May 2007. DTI

[12] Warm front scheme: The Warm Front Scheme is designed to assist homeowners and tenants in England to more efficiently heat their homes. thus reducing heating bills as well as carbon emissions. http://www.uk-energy-saving.com/warm_front_scheme.html

[13] Fuel poverty: A household is said to be in fuel poverty if it needs to spend more than 10 per cent of its income on fuel to maintain a satisfactory heating regime (usually 21 degrees for the main living area. and 18 degrees for other occupied rooms). The latest available estimates suggest that some two million households in the UK in 2004 were in fuel poverty. and thus had difficulty in keeping their homes warm at an acceptable level of cost. http://www.dti.gov.uk/energy/fuel-poverty/index.html

[14] Dobson. A. (2003). "Citizenship and the Environment". Oxford University Press. Fleming. D. (2005). "Energy and Common purpose – Descending the energy staircase with tradable energy quotas". The Lean Economy Connection. Hillman. M & Fawcett. T.(2004). "How we can save the planet". Penguin Books.

[15] The climate change levy is a tax on the use of energy in industry. commerce and the public sector. with offsetting cuts in employers' National Insurance Contributions and additional support for energy efficiency schemes and renewable sources of energy. The aim of the levy is to encourage users to improve energy efficiency and reduce emissions of greenhouse gases.

Alternative approach is energy rationing. A new proposal, "Personal Carbon Trading" (PCT) has been looked into by the government as one of long term policy options.[16] There are a few variations in defining a boundary of PCT such as "Tradable Energy Quotas" proposed by David Fleming and "Personal Carbon Allowances" suggested by Meyer Hillman and Tina Fawcett.[17] The fundamental concept of personal carbon trading is based on setting an overall emissions cap and distributing emissions rights equally across the population. These "carbon credits" are surrendered upon the purchase of household energy such as gas and electricity and fuel for transport. Those who need or want to emit more than their allowance, will have to buy allowances from those who emit less i.e. those who have surplus of allowances. Over time, the overall emissions cap (and hence individual allocations) could be reduced in line with international or nationally adopted agreements.[18]

The possible benefits of personal carbon trading include its effectiveness to manage CO_2 emissions reduction at the national level by engaging individuals and households in the scheme and its apparent democratic nature that it empowers people providing flexibility in how they manage their own carbon credits. However, PCT is largely untested and its feasibility in practice is unknown due to the minimal empirical data available. There are also uncertainties with regards to perceived fairness of the system and acceptance by the public.[19]

2.4 Summary

The majority of UK households are largely energy inefficient. As the UK economy grows, the personal energy consumption is expected to rise as the number of household appliances owned by the average household is expected to increase and more people are going to travel. Whilst the improved energy efficiency of household appliances and the improved fuel efficiency of cars may contribute to some reduction in CO_2 emissions, uncontrolled energy demand from individuals can easily negate the effects of energy efficiency. This thesis investigates the personal carbon dioxide emissions using a case study of healthcare professionals. It endeavours to explore the method of calculating individual CO_2 emissions and profile personal energy consumptions which then can be used to identify possible areas where energy saving and CO_2 emissions reduction can be made. The study is also designed to observe

[16] http://www.defra.gov.uk/environment/climatechange/uk/individual/pca/index.htm
[17] Fleming. D. (2005). Hillman. M. & Fawcett. T. (2004)
[18] http://www.defra.gov.uk/environment/climatechange/uk/individual/pca/index.htm
[19] Starkey, R. & Anderson. K. "Domestic Tradable Quotas, A policy instrument for reducing greenhouse gas emissions from energy use. Technical Report 39. December 2005. Tyndall Centre for Climate Change Research

personal views on current environmental problems and possible legislation such as taxation and personal carbon trading as aforementioned.

Chapter 3: Calculation of Personal Direct CO_2 emissions

This chapter reviews a method of calculating direct CO_2 emissions and its limitations. The scope of personal direct CO_2 emissions was confined to household energy use such as electricity and gas and personal travels including cars and flights. Although most individuals use public transport such as rail and bus services, collecting the reasonably accurate data for the distance travelled on public transport was problematic, public transport was excluded from the scope of calculating direct CO_2 emissions. The methodology of calculating CO_2 emissions from each component is discussed below.

3.1 CO_2 calculator

There are several carbon footprint calculators which enable individuals to estimate how many tonnes of carbon dioxide they are responsible for emitting. A range of on-line CO_2 calculators were consulted to identify a suitable method of estimating CO2 emissions. [20] A simple activity based input-output calculation approach was chosen as a suitable method for its robustness and ease of use. This method requires the inputs of energy consumption data from users e.g. annual gas bill, annual car mileage and CO_2 conversion factors to estimate CO_2 emissions associated with each activity. A questionnaire included specific questions which were designed to collect consumption data such as gas and electricity, car mileage and flight details. CO_2 conversion factors were obtained from Department of Food, Rural and Agriculture (DEFRA) to enable this calculation. [21]

3.2 CO_2 emissions from Household

Most households use gas and electricity provided by power suppliers to heat, light and use household appliances at home. Unless, energy comes from renewable sources such as solar panel and wind turbine, there are CO_2 emissions associated with household energy consumption. CO_2 emissions from household energy use can by calculated by multiplying the fuel units consumed and CO_2 conversions factors. The survey included questions on the estimates for annual electricity and gas consumptions which can be answered either in consumption units (kWh) or bills (GBP). If the annual electricity and

[20] http://actonco2.direct.gov.uk/index.html, http://www.climatecare.co.uk/, http://www.carbonneutral.com.
[21] Guidelines to Defra's GHG conversion factors for company reporting, June 2007, Defra

gas consumption were given in currencies, consumption units were determined by using the average cost of electricity and gas.[22]

An example below shows how CO_2 emissions from annual electricity bill of £200 and annual gas bill of £250 can be calculated. (Note: It was assumed that these bills were given by a Nottingham resident and the average cost of electricity and gas for Nottingham were used.)

An Example: Calculating CO_2 emissions from electricity and gas

Items	**Number**	**Sources**
Annual Electricity Bill	£200	Survey
Annual Gas Bill	£250	Survey
Average cost of electricity in Nottingham (direct payment method selected)	8.94 p/ kWh	DTI
Average cost of gas in Nottingham (direct payment method selected)	2.35 p/ kWh	DTI
CO_2 conversion factor for electricity	0.43 kg CO_2/ kWh	DEFRA
CO_2 conversion factor for gas	0.19 kg CO_2/ kWh	DEFRA

Annual electricity consumptions = £200 x 100 / 8.94 = 2,237.1kWh
Annual CO_2 emissions from electricity consumptions = 2,237.1 x 0.43 = 962.0kg

Annual gas consumptions = £250 x 100 / 2.35 = 10,638.3kWh
Annual CO_2 emissions from gas consumption = 10,638.3 x 0.19 = 2,021.3kg

Total annual CO_2 emission for a household = 962.0 + 2,021.3 = 2,983.3kg

This figure is for the entire household and if the house was occupied by more than one person, the household CO_2 emissions should be divided by the number of people living in the house in order to determine the individual allocation of the household CO_2 emissions.

[22] The average cost of electricity and gas are obtained from energy price (DTI). Quarter Energy Prices. June 2007. A national statistics publication. Department of Trade and Industry

3.2 CO_2 emissions from personal car travels

The amount of CO_2 emitted from a car depends on the fuel economy of a car, distances travelled, load, age of car and driving pattern etc. The fuel economy of cars such as miles per gallon (MPG) can be used to estimate the amount of CO_2 emitted for the distance travelled. CO_2 emissions figures expressed in CO_2 emissions per km travelled (g CO_2 / km) are now available for newer cars.

It would be ideal to obtain the actual CO_2 conversion factor for each car model, however, determining the appropriate CO_2 factor for older cars would be unfeasible, it was decided that cars would be categorised based on fuel type and engine size and the standard conversion CO_2 factors for each group of cars would be used. Figure 3.3.1 shows CO_2 conversion factors for passenger cars according to fuel type and engine size provided by DEFRA.

The questionnaire included questions on annual car mileage, petrol, model and size of engine to categorise the cars owned by survey participants. Then, CO_2 emissions from car travel can be calculated by multiplying the appropriate CO_2 conversion factor by the annual car mileage.

Figure 3.3.1 Passenger road transport conversion factors (Source: Defra)[23]

Type	Fuel Type	Engine Size	CO2 Conversion Factor (kg CO2/mile)	CO2 Conversion Factor (kg CO2/km)
A	Petrol	Small (Up to 1.4L)	0.2947	0.1831
B		Medium (1.4L ~ 2.0L)	0.3479	0.2162
C		Large (Above 2.0L)	0.477	0.2964
D	Diesel	Small (Up to 1.7L)	0.2425	0.1507
E		Medium (1.7 ~ 2.0L)	0.3027	0.1881
F		Large (Above 2.0L)	0.424	0.2675

Cars may be shared among several users in the household. Since it is difficult to determine the accurate sharing ratio by different drivers, it was decided that annual CO_2 emissions would be divided by the number of people in the house aged 17 or over (taking account of the minimum legal driving age in the UK) to determine CO_2 emissions per person. Some households own more than one car and in this case CO_2 emissions from all cars are added together and these are divided by the number of people in the house aged 17 or over. Although this does not represent the accurate personal car usage, CO_2 emissions associated with all cars owned by survey participants and their households would be taken into account

[23] Guidelines to Defra's GHG conversion factors for company reporting, June 2007, DEFRA

in calculation in this way. CO_2 emissions associated with car rental was also included by collecting information on the annual estimate of car mileage and the typical type of cars e.g. size of engine, fuel type etc.

3.3 CO_2 emissions from Flights

Estimating the amount of CO_2 emitted from a flight is more complex than road transportation because fuel consumed does not scale linearly with distance travelled due to the extra fuel burn required to lift the plane up to cruising altitude, and the necessity to carry large quantities of fuel for long distance. A number of studies have been conducted to estimate the appropriate CO_2 emission factors for long haul and short haul flights. The factors that should be taken into account include type of aircraft, distance travelled, weather conditions, cargo load, passenger load and flight altitude, typical routes taken etc. The different assumptions and methodology used in estimating these factors result in different CO_2 conversion factors. As aforementioned, for this thesis, CO_2 conversion factors from DEFRA were used for CO_2 estimations.

However, it is important to note that the conversion factors used by DEFRA do not take into account of the radiative forcing index. It has been argued that aviation emissions may have a greater climate impact than the same emissions made at ground level because emissions at altitude can instigate a host of chemical and physical processes that have climate change consequences.[24] In order to account for this impact, a multiplier is used to quantify the potentially greater impact of aviation emissions. The radiative forcing index is the most commonly used multiplier and Intergovernmental Panel of Climate Change (IPCC) previously estimated that the impact of radiative forcing was 2.7 times that of CO_2 alone.[25] However, IPCC also acknowledged that the actual scale of impact is unknown that it could range from 2 to 4 times of CO_2 impact alone. A more recent study revised this figure to 1.9 and this is now considered as the best quantified estimate of radiative forcing index of aviation emissions. [26]

---

[24] Jardine. C. N (2005). *Part 1: Calculating the environmental impact of aviation emissions & Part 2: Making sense of the science " A review of climate care's approach to accounting for aviation emissions "*. Environmental Change Institute. Oxford University Centre for Environment. Oxford

[25] Houghton et al (2001) "Climate Change 2001 – The Scientific Basics", IPCC, Cambridge University Press, Cambridge

[26] http://www.iac.ethz.ch/tradeoff/

Estimating CO_2 emissions using the recommended DEFRA's factors alone is likely to result in underestimated CO_2 emissions from flights. Therefore, it was decided that CO_2 emissions from flights would be calculated both exclusive and inclusive of the radiative forcing index. A multiplier of 2 was used to quantify the radiative forcing impact for this exercise as this was commonly used by carbon offsetting companies.[27]

Table 3.4.2 shows CO_2 conversion factors for short and long haul flights. These factors include an uplift factor of 9% which takes into account of delays and circling suggested by IPCC.[28] Long haul flights are more energy efficient than short haul flights on average as most energy are used during take off and landing and hence, long haul flights have a smaller conversion factor. A flight distance less than 3,500km is categorised short haul flight and a flight distance over 3,500km is categorised long haul flight. The Carbon Neutral Company's flight distance calculator was used to derive a flight distance for each flight.[29]

Table 3.4.2 CO_2 conversion factors for short and long haul flights

Flight distance (km)	CO_2 conversion factor (kg CO_2 /passenger km)	Uplift factor
Long haul (>3,500km)	0.1056	109%
Short haul (<3,500km)	0.1304	109%

An example below shows estimation of CO_2 emissions associated with a return flight from London to New York.

CO_2 emissions from a flight excluding Radiative forcing
= Distance x CO_2 conversion factor
= 11,082 km x 0.1056 x 109%
=1,275.6kg

To account for the impact of radiative forcing, this is multiplied by 2

1.275.6 x 2 = 2,551.2 kg

[27] Jardine. C. N (2005) Part 2: Making sense of the science " A review of climate care's approach to accounting for aviation emissions", Environmental Change Institute, Oxford University Centre for Environment, Oxford
[28] Guidelines to Defra's GHG conversion factors for company reporting, June 2007, DEFRA
[29] http://www.carbonneutral.com

Chapter 4: Designing a Questionnaire

Chapter 3 discussed the method of calculating personal carbon dioxide emissions. In order to profile individual energy consumption pattern, it is necessary to obtain additional information that affect energy consumption. A questionnaire can be a useful tool to gather specific information. A challenge for using a questionnaire is that time given for the questionnaire is limited and thus questions have to be selective and understandable for survey respondents. This section discusses the design of the questionnaire and limitations with the questionnaire approach to carry out this study.

4.1 Summary

The questionnaire has a total of 50 questions regarding household energy consumption, heating systems, household appliances, car ownership, personal travel pattern, flights, personal attitudes towards the environmental problems etc. A copy of the questionnaire is included in Appendix A. Most questions have predefined answers to assist participants and engage them into reviewing their energy consumption profiles. A questionnaire was also used as a framework for semi-structured interviews to obtain personal views and feedback from survey participants.

4.2 Household Energy Consumption

There are several factors that affect household energy consumption. These factors include building form, fabric, size, heating system, use of household appliances, climate and microclimate, occupancy patterns, fuel costs and type etc. Due to a limited time given for a questionnaire, questions were selected based on the following categories.

- Thermal standard of housing
- Occupancy pattern
- Heating systems
- Appliances
- Energy efficient measures

Thermal standard of housing

As discussed in Chapter 2, nearly three quarters of household energy consumption come from space and water heating. Heating demand is largely affected by thermal standard of housing such as building fabric, glazing, air tightness etc. In order to estimate the thermal characteristic of the housing, the questions on the dwelling age (e.g. Pre 1919, Post 1919 to1945), the dwelling type (e.g. flat, terraced house, semi-detached etc) and the dwelling size by the number of bed rooms in the house were included. These questions were not sufficient to identify the thermal standard of different houses and this study is certainly not designed to assess the energy performance of the houses by a questionnaire, but collect basic information that affect household energy consumptions. Albeit basic, the information on dwelling age, type and size can be a good indicator to quickly assess the thermal standard of housing and moreover the questions would be more understandable to survey participants.

Occupancy patterns

Occupancy patterns and occupant behaviours can largely affect household energy consumption. For example, a retired couple spends more time in the dwelling than a working couple and their energy consumption is likely to be higher through more heating, lighting etc. In order to estimate occupancy pattern, the questions on the number of people in the house and the age of each individual were included. From these, the size and type of household can be identified.

Heating system

The type of heating systems and fuel can affect energy consumption significantly. For instance, electricity is more carbon intensive than natural gas and higher CO_2 emissions can be expected from a household employs electric heating system compared to a household with central gas heating system though the actual heating demand is largely dependent on the thermal standard of housing and occupancy behaviours. A modern gas condensing boiler is approximately 90% efficient whereas the old conventional boiler is around 65 ~ 70% efficient.[30] The insulation around hot water cylinder can reduce heat loss that can save energy and CO_2 emissions. A series of questions on heating systems e.g. fuel type, boiler type, boiler age etc were included in the questionnaire.

[30] http://www.energysavingtrust.org.uk/energy_saving_products/types_of_energy_saving_recommended_products/boilers_and_heating_controls

Appliances

Domestic energy consumption from household appliances is increasing due to a rise in the number of household appliances owned by households. Some household appliances such as fridges and freezers can be energy demanding because they are used for 24 hours 7 days throughout a year. The age and energy efficiency rating of these appliances would make a large difference in electricity consumptions. The questionnaire included the ownership of certain appliances and the particular attentions were given to fridges and freezers and televisions.

Energy efficiency measures

There are several energy efficiency measures such as loft insulation, energy efficient light bulbs etc that consumers can implement to save energy and CO_2 emissions. The questions on the uptake of the following measures, energy saving light bulbs, draught proofing, double glazing and solar water heating were included. A question on the ownership of house was also included to observe the uptake rate of energy efficiency measures among home owners.

4.2 Personal travels

Car travels

In order to calculate CO_2 emissions, the questions on the following details – annual mileage, car model, size of engine, fuel used were included. In order to profile personal travelling patterns, questions on commuting methods, distance between work and home, frequency of food shopping by car were also included.

Flights

In order to calculate CO_2 emissions from flights, following details of flight information were asked – origin, destination, the number of journeys, return/single. The flight details were requested for those that were taken in the past year. In addition, the purpose of flying i.e. business or other was asked to review personal flying patterns.

4.3 Semi-structured interviews

A questionnaire included a number of questions concerned with personal behaviours and attitudes towards the current environmental issues. These questions were used as a framework for semi-structured interviews to obtain personal views and identify the barriers that survey respondents face in making CO_2 reductions at the personal level. The survey responses from these interviews will be discussed in Chapter 8.

4.4 Limitations

Although a questionnaire can be a useful tool to collect specific data, several limitations were expected using the approach. Firstly, the answers given by survey respondents would be entirely based on their self-assessment and this may not necessary represent the accurate picture. Secondly, the quality of answers would be largely dependent on the level of knowledge the individuals have on the subjects and this is likely to vary among individuals depending on their circumstances. For example, a person who has lived in the same property for several years has a better knowledge of his/her heating systems etc compared to a person who has just moved into a new property for a few months. Thirdly, the number of questions that can be asked in the questionnaire is limited and therefore, this is likely to set the limit for the scope of possible data analysis.

Chapter 5: CO_2 emissions from Household energy use

This chapter analyses CO_2 emissions associated with household energy use including gas and electricity. The energy consumption patterns of different household types were analysed based on housing structure, heating systems and the ownership of household appliances. The uptake rate of different energy efficiency measures among the survey participants is also reviewed.

5.1 A survey sample size

The survey was conducted among a total of 37 healthcare professionals employed at Queens Medical Centre, Nottingham. A sample population consists of 20 doctors including 4 hospital consultants, 9 registrars, 3 senior house officers (SHOs) and 4 junior house officers (JHOs) and 17 other healthcare professions including 11 nurses, 4 occupational therapists (OTs) and 2 physio therapists (PTs). Figure 5.1.1 shows the breakdown of a sample population by professional type and gender. Figure 5.1.2 shows the breakdown of a sample population by household type.

Figure 5.1.1 A breakdown of a sample population by professional type

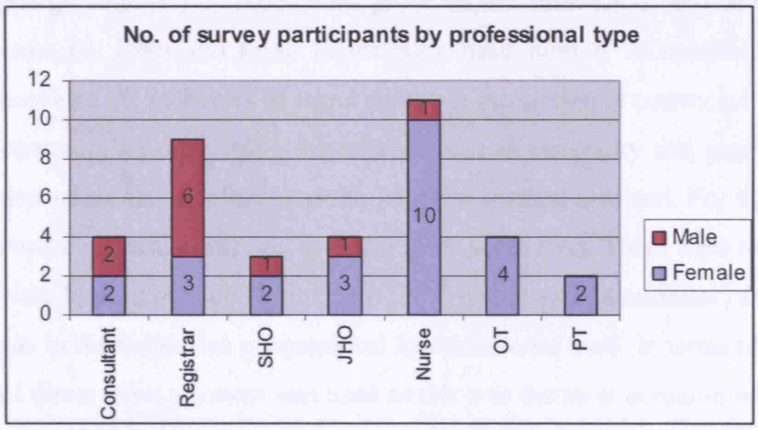
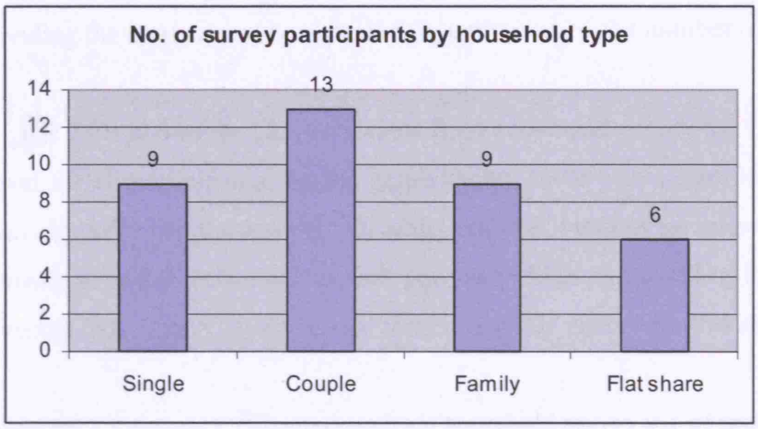


Figure 5.1.2 A sample population by household type



5.2 CO_2 emissions calculation for gas and electricity use

Annual direct CO_2 emissions from household energy use were calculated from annual gas and electricity consumption. (Note: There was no participant who subscribed electricity from renewable energy sources.) 3 respondents provided the estimate of annual energy consumption in consumption units i.e. kWh and these inputs were used directly to calculate CO_2 emissions. Most respondents provided the estimates of annul energy consumption in currencies i.e. GBP and these were converted to consumption units using the average cost of electricity and gas.[31] The average cost of energy varies depending on suppliers and the payment method selected. For those live in Nottingham, the average cost of gas and electricity in Nottingham were used. There were two participants whose primary homes were located outside Nottingham (i.e. London and Manchester) and the average cost of electricity and gas in the respective geographical locations were used. In terms of a payment method, the average cost of direct debit payment was used as this was the most common method of payment used by the survey respondents. Annual energy consumption was multiplied by the CO_2 conversion factors, 0.19 kg CO_2/ kWh for gas and 0.43 kg CO_2/ kWh for electricity to determine CO_2 emissions associated with each fuel use.[32] For those live in multiple occupancy households such as couples and families, the

[31] The average cost of electricity and gas are obtained from energy price (DTI). Quarter Energy Prices, June 2007, A national statistics publication, Department of Trade and Industry
[32] Guidelines to Defra's GHG conversion factors for company reporting, June 2007, Defra

individual contribution of CO_2 emissions from the shared use of household energy was calculated by dividing the total annual household CO_2 emissions by the number of people in the household.

Figure 5.2.1 shows the CO_2 emissions from household energy use both at the individual and household level for all participants. As the graph shows, there was a significant variation in the individual CO_2 emissions. P1 had the lowest CO_2 emissions at 0.9 tonnes per person per year and D19 had the highest emissions at 8.0 tonnes per person per year which amounted to 8.6 times more than that of P1. The average individual CO_2 emissions from household energy for this sample were 2.4 tonnes per year.

Figure 5.2.1 Annual CO_2 emissions from household energy use at individual and household level

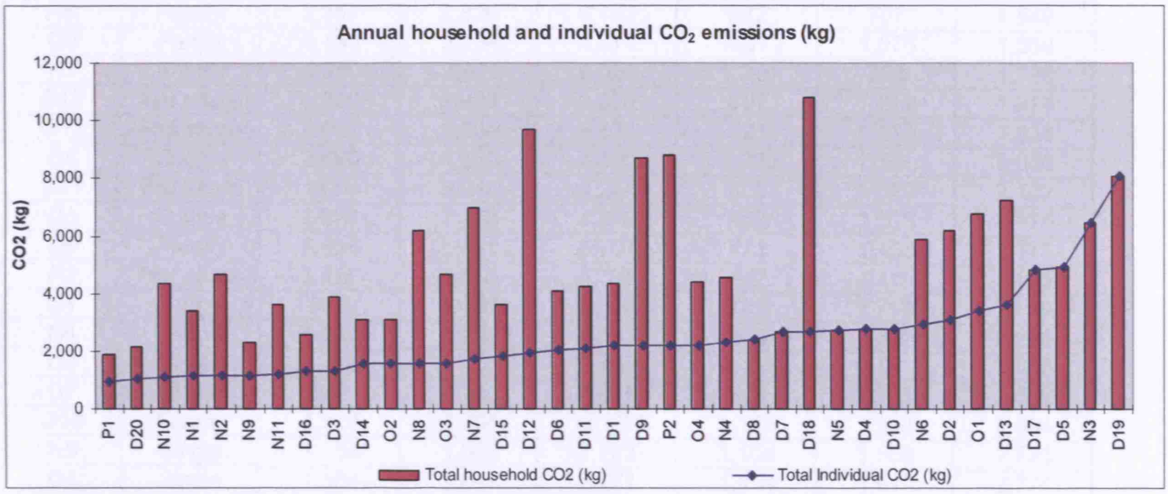


Table 5.2.1 Annual CO_2 emissions from household energy use at individual and household level

ID number	Household Type	Household Electricity CO2 (kg)	Household Gas CO2 (kg)	Total household CO2 (kg)	Individual Electricity CO2 (kg)	Individual Household Gas CO2 (kg)	Total Individual CO2 (kg)
P1	Couple	577	1,294	1,871	289	647	935
D20	Couple	1,154	970	2,125	577	485	1,062
N10	*Family*	*1,924*	*2,426*	*4,349*	*481*	*606*	*1,087*
N1	Family	1,443	1,940	3,383	481	647	1,128
N2	Family	1,732	2,911	4,642	433	728	1,161
N9	Couple	866	1,455	2,321	433	728	1,161
N11	*Flat share*	*1,202*	*2,426*	*3,628*	*401*	*809*	*1,209*
D16	Couple	962	1,617	2,579	481	809	1,289
D3	Family	1,443	2,426	3,868	481	809	1,289
D14	*Flat share*	*1,154*	*1,940*	*3,095*	*577*	*970*	*1,547*
O2	Couple	1,154	1,940	3,095	577	970	1,547
N8	*Family*	*3,367*	*2,830*	*6,197*	*842*	*707*	*1,549*
O3	Family	1,443	3,234	4,677	481	1,078	1,559
N7	Family	4,040	2,911	6,951	1,010	728	1,738
D15	*Flat share*	*1,202*	*2,426*	*3,628*	*601*	*1,213*	*1,814*
D12	Flat share	3,607	6,064	9,671	721	1,213	1,934
D6	Couple	2,580	1,520	4,100	1,290	760	2,050
D11	Flat share	1,204	3,040	4,244	602	1,520	2,122
D1	Couple	1,924	2,426	4,349	962	1,213	2,175
D9	Family	2,886	5,821	8,707	721	1,455	2,177
P2	*Flat share*	*3,126*	*5,660*	*8,786*	*782*	*1,415*	*2,196*
O4	*Couple*	*962*	*3,436*	*4,398*	*481*	*1,718*	*2,199*
N4	Couple	1,347	3,234	4,581	673	1,617	2,290
D8	Single	2,405		2,405	2,405	0	2,405
D7	Single	547	2,111	2,657	547	2,111	2,657
D18	Family	4,714	6,064	10,777	1,178	1,516	2,694
N5	Single	1,154	1,569	2,723	1,154	1,569	2,723
D4	Single	1,154	1,617	2,771	1,154	1,617	2,771
D10	Single	1,828	970	2,798	1,828	970	2,798
N6	Couple	3,463	2,426	5,889	1,732	1,213	2,944
D2	Couple	1,347	4,851	6,198	673	2,426	3,099
O1	*Couple*	*1,924*	*4,851*	*6,775*	*962*	*2,426*	*3,388*
D13	Couple	7,215		7,215	3,607	0	3,607
D17	Single	794	4,043	4,836	794	4,043	4,836
D5	*Single*	*1,586*	*3,339*	*4,925*	*1,586*	*3,339*	*4,925*
N3	Single	1,924	4,528	6,452	1,924	4,528	6,452
D19	Single	1,270	6,791	8,061	1,270	6,791	8,061

5.3 Annual gas and electricity consumption for different household types

Table 5.3.1 shows the average annual bill, consumption and CO_2 emissions for gas at household and individual level (per person) for different household groups including "single", "couple", "family" and "flat share". The average household gas consumption was higher for larger household groups such as "family" and "flat share". The individual CO_2 emissions were calculated by the total household CO_2

emissions divided by the number of people in the household. After allocating CO_2 emissions per person, the average individual CO_2 emissions were highest for "single" households.

Table 5.3.2 shows the average annual bills, consumption and CO_2 emissions for electricity for those employ gas heating systems and electric heating systems respectively. A similar trend can be observed in electricity consumption that the average CO_2 emissions were higher for "family" households, but after allocation, the average individual CO_2 emissions were highest for "single" household group. In both cases, the participants who live in single occupancy households have higher CO_2 emissions per person compared those live in multiple occupancy households.

The sample contained 9 family households and 4 families had young children aged from 1 year old to 11 years old. The detailed analysis of energy consumption for different type of family households (e.g. a family with young babies vs a family with children of primary school age etc) to observe energy demand from children was not feasible due to a limited amount of sample and data.

Table 5.3.1 Average annual household gas consumptions per household type

	Household Type				
Data	Single	Couple	Family	Flat share	All
No. of responses	7	11	9	5	32
Average Gas Bill (GBP)	387	286	420	444	368
Average Gas Consumption (kWh)	16,426	13,167	17,872	18,908	16,106
Average Gas CO2 emissions (kg)	3,121	2,502	3,396	3,592	3,060
Average Gas CO2 emissions (kg) - Allocation	*3,121*	*1,155*	*919*	*1,190*	*1,497*

Table 5.3.2 Average annual household electricity consumptions per household type for gas heating system and electric heating system

	Household Type				
Gas Heating System	Single	Couple	Family	Flat share	All
No. of responses	7	11	9	5	32
Average Electricity Bill (GBP)	255	323	531	430	383
Average Electricity Consumption (kWh)	2,800	3,616	5,941	4,811	4,278
Average Electricity CO2 emissions (kg)	1,204	1,555	2,555	2,069	1,840
Average Electricity CO2 emissions (kg) - Allocation	*1,204*	*778*	*679*	*621*	*819*
Electric Heating System	Single	Couple	Family	Flat share	All
No. of responses	2	2		1	5
Average Electricity Bill (GBP)	440	870		240	572
Average Electricity Consumption (kWh)	4,922	9,732		2,685	6,398
Average Electricity CO2 emissions (kg)	2,116	4,185		1,154	2,751
Average Electricity CO2 emissions (kg) - Allocation	*2,116*	*2,092*		*577*	*1,799*

5.4 Housing structure

A series of questions concerned with housing structures e.g. housing age, housing type and housing size were included in the questionnaire. 32 out 37 respondents had gas central heating systems. In order to compare heating demand for different housing types, the average gas consumption for each household group that employ gas central heating systems were compared. Table 5.4.1 shows the average annual household gas consumption for different housing type and housing size. A caution needs to be taken when analysing this data because households have different type of boilers (e.g. conventional boiler vs condensing combi boiler) and cooking systems (e.g electric hob vs gas hob). Despite these differences, a general trend was observed that larger houses e.g. 5-6 bed room detached houses, have higher gas consumption compared to smaller houses e.g. 1-2 bed room flats. The higher gas consumption indicates large heating demand possibly due to heat loss through large exposed areas, however, no conclusion can be drawn from this observation due to a limited size of sample and an absence of other data such as building form, fabric, occupancy behaviours etc. No trend between energy consumption and housing age was observed.

Table 5.4.1 Average annual gas consumption and housing type and size

Housing Type	Data	Hosuing Size (No. of Bed rooms)						
		1	2	3	4	5	6	All
Flat	Average Gas Consumptions (kWh)	16,745	9,929					13,824
	No. of responses	4	3					7
Mid Terrace	Average Gas Consumptions (kWh)		7,660	10,511		31,915		15,149
	No. of responses		1	2		1		4
End Terrace	Average Gas Consumptions (kWh)		23,830		29,787			26,809
	No. of responses		1		1			2
Semi-detached	Average Gas Consumptions (kWh)		16,000	14,539	15,745	8,000		14,334
	No. of responses		1	9	2	1		13
Detached	Average Gas Consumptions (kWh)			26,383	12,766	30,638	31,915	23,475
	No. of responses			2	2	1	1	6
All	Average Gas Consumptions (kWh)	16,745	12,879	15,741	17,362	23,518	31,915	16,818
	No. of responses	4	6	13	5	3	1	32

5.5 Heating systems

Amongst 32 participants who employed gas central heating systems, 15 participants had condensing combi-boiler and 17 participants had conventional boiler. (See Figure 5.5.1) Table 5.5.1 shows the average annual household gas consumption for those employ condensing combi-boiler and those with conventional boiler for each household type. Both gas consumption and bills were lower for those with condensing boiler for all household types possibly due to higher efficiency of condensing boiler.

Figure 5.5.2 show the age of conventional boiler owned by participants. The participants who own old conventional boiler (10 years old or more) could benefit from upgrading the existing one to a modern condensing boiler. Both money and energy (therefore CO_2 emissions) can be saved by this upgrade.

Table 5.5.1 Average annual bill, consumption, CO_2 emissions for gas compared between condensing combi boiler and conventional boiler types

		Household Type				
Boiler type	Data	Single	Couple	Family	Flat share	All
Combi	Average Gas Bill (GBP)	329	304	328	376	322
	Average Gas Consumption (kWh)	13,904	12,943	13,936	16,000	13,668
	Average Gas CO2 emissions (kg)	2,642	2,459	2,648	3,040	2,597
Conventional	Average Gas Bill (GBP)	554	330	494	513	461
	Average Gas Consumption (kWh)	23,561	14,026	21,021	21,809	19,597
	Average Gas CO2 emissions (kg)	4,477	2,665	3,994	4,144	3,723

Figure 5.5.1 Type of boilers owned by participants

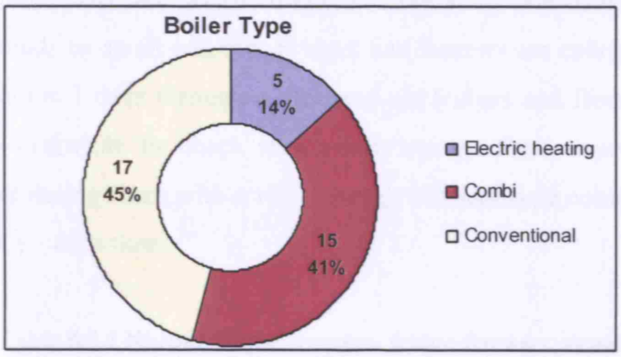
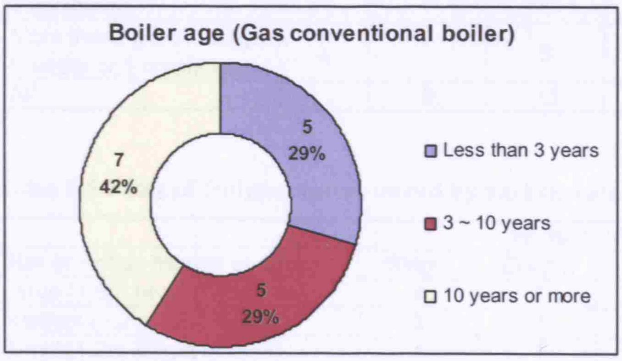


Figure 5.5.2 Age of gas conventional boilers owned by participants



5.5 Household appliances

Cold appliances – fridges, freezers & fridge freezers

Table 5.5.1 shows the number of fridges, freezers or fridge-freezers owned by the survey participants. Those who own more than one set of fridge and freezer or 1 fridge-freezer combined tend to be families and couples. The survey showed that 26 participants owned fridge-freezers and Table 5.5.2 shows the size of fridge-freezers owned by the participants of different household types. The height of fridge-freezer was used for grouping by size (i.e. Large: 1.8 m height or above, Medium: 1.2 m ~ 1.7 m height, Short: 1.2 m height or below). As Table 5.5.2 shows, most people own large fridge freezers. Although a 1.8 m height or above was indicated for "large" size, some participants of family household type had significantly large fridge freezers such as an American style fridge freezer. Table 5.5.3 shows the age of fridges, freezers and fridge-freezers. The survey showed that those households that own more than one set of fridge and freezer or one fridge-freezer, their supplementary fridge or freezer tends be small and old. Fridges and freezers are energy demanding appliances as they are used for 24 hours 7 days through a year and old fridges and freezers can be very energy inefficient.[33] It may be worthwhile to check how much energy these supplementary fridges and freezers are using and replacing them with a more energy efficient type could bring some saving both in terms of money and CO_2 emissions.

Table 5.5.1 No. of fridges, freezers, fridge-freezers owned by participants

	Household Type				
No. of Fridge/Freezer/Combined	Single	Couple	Family	Flat share	All
1 set of Fridge & Freezer or 1 combined	9	10	4	5	28
More than1 set of Fridge & Freezer or 1 combined		3	5	1	9
All	9	13	9	6	37

Table 5.5.2 Size of fridge-freezers owned by participants

	Household Type				
Size of Fridge freezer combined	Single	Couple	Family	Flat share	Total
Large (1.8m height or above)	4	6	6	3	19
Medium (1.2 ~ 1.8m height)	2	2		1	5
Small (1.2m height or less)	1	1			2
Total	7	9	6	4	26

[33] http://www.energysavingtrust.org.uk/energy_saving_products/types_of_energy_saving_recommended_products/refrigeration_products/Energy trust

Table 5.5.3 Age of fridge-freezers, fridges, freezers owned by participants

	Fridge freezer	Fridge	Freezer	All
Less than 3 years	8	1	1	10
3 ~ 10 years	16	12	12	40
10 years or more	2	2	4	8
Total	26	15	17	58
Average age (years)	3.7	5	5.9	4.7

Consumer electronics – Televisions (TVs)

Table 5.5.4 shows the number of TVs owned by participants of different household types. Families tend to own multiple number of TVs. Figure 5.5.3 shows the type of TVs owned by participants. Most TVs were CRT (cathode ray tune) type and the next popular type was LCD. According to DEFRA's CO2 calculation methodology paper, the average power consumption is higher for LCD TVs than CRT TVs when they are switched on, however, CRT TVs have relatively high power consumption during "stand by" mode compared to LCD TVs. (See Table 5.5.5) Those households with many CRT TVs at home can achieve some CO_2 emissions saving by switching off TVs properly.

As the number of household members increases, household needs increase e.g. more cold storage for food, more TVs, more washing and drying to be made etc. Thus, family households often have larger or more number of household appliances which could relate to higher electricity consumption by family household types. (See Table 5.3.2)

Table 5.5.4 No. of TVs owned by participants

	Household Type				
No. of TVs	Single	Couple	Family	Flat share	Total
0	1	1			2
1	7	5		1	13
2	1	6	2	4	13
3		1	4		5
4			2	1	3
5			1		1
Total	9	13	9	6	37

Figure 5.5.3 Type of TVs owned by participants

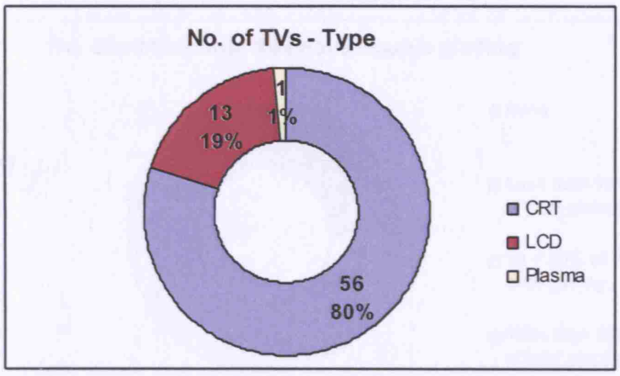


Table 5.5.5 Average power consumption of new televisions (Source: Defra)[34]

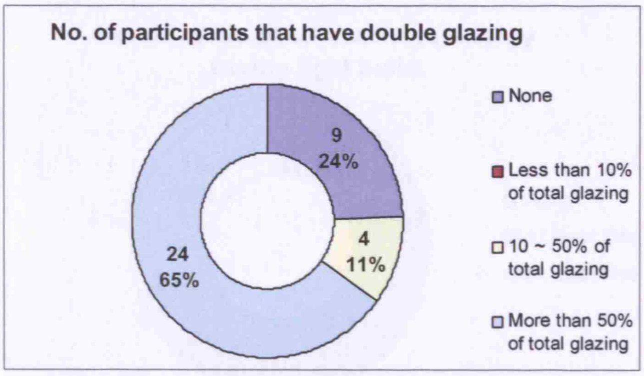
TV technology	Typical size, inch	Typical Aspect	On Power (W)	Watts per cm^2	Stand-by power (W)
CRT	28	4:3	120.1	0.04798	2.9
LCD	32	16:9	148.0	0.04667	1.7
Plasma	42	16:9	305.5	0.05592	3
Rear Projection	42	16:9	261.7	0.02227	2
All				**0.04791**	**2.5**

5.6 Uptake of energy efficiency measures

The survey included questions on the uptake of a number of energy efficiency measures including solar water heating system, double glazing, drought proofing and energy saving light bulbs. Figure 5.6.1 ~ 5.6.3 show the uptake rate of each energy efficiency measure. (Note: No participants had solar water heating systems.)

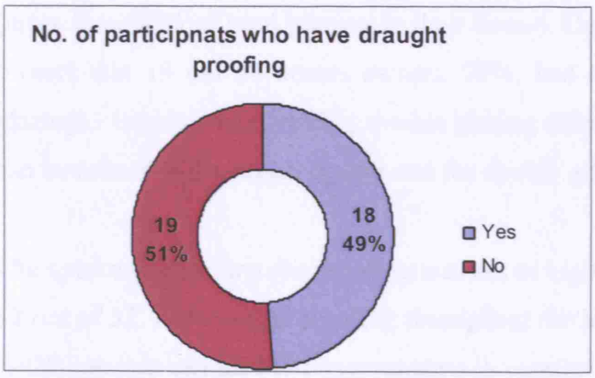
[34] Act on CO2 calculator: Public trial version, Data, methodology and assumptions paper, June 2007, Defra

Figure 5.6.1 Uptake rate for double glazing



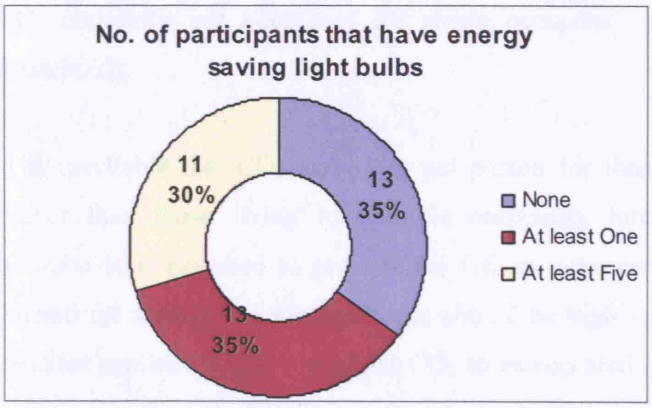
Double glazing ratio	Owner	Tenant	Total
None	3	6	9
Less than 10% of total glazing	0	0	0
10 ~ 50% of total glazing	2	2	4
More than 50% of total glazing	19	5	24
Total	24	13	37

Figure 5.6.2 Uptake rate for draught proofing



Draught Stripping	Owner	Tenant	Total
Yes	13	5	18
No	11	8	19
Total	24	13	37

Figure 5.6.3 Uptake rate for energy saving light bulbs



Energy efficient lighting	Owner	Tenant	Total
None	7	6	13
At least One	8	5	13
At least Five	9	2	11
Total	24	13	37

The uptake rate for double glazing was high that 24 out of 37 participants (65%) had double glazing (more than 50% of total glazing in their home). Double glazing was extremely popular among home owners that 19 out 24 homes owners, 79%, had double glazing installed (more than 50% of total glazing). Beside energy saving, double glazing offers practical benefits such as safety and security that can be related to the higher uptake rate for double glazing amongst this case study sample.

The uptake rate for draught proofing was not as high as double glazing that about a half of participants, 18 out of 37, had draught proofing throughout the house. Draught proofing is a simple Do It Yourself (DIY) job that can lead to improvements in comfort and potentially reduce heating bills.[35] Despite the recent campaigns and reductions in prices, the uptake rate of energy saving lights bulbs was relatively low that only 11 out of 37 participants (30%) had at least 5 energy saving light bulbs in their home.

5.7 Discussion

The total annual CO_2 emissions from gas and electricity for this cohort of healthcare professionals amount to 179.8 tonnes, 4.9 tonnes per household and 2.4 tonnes per person. The average CO_2 emissions per person were highest for those living in single occupancy households compared to those

[35] http://www.energysavingtrust.org.uk/home_improvements/home_insulation_glazing/draught_proofing

in multiple occupancy households such as "Family" and "Flat share". In general, the average annual CO_2 emissions per household for single occupancy households were higher that that of couple households.

It is inevitable that CO_2 emissions per person for those living in single occupancy households are higher than those living in multiple occupancy households. The number of single occupancy households is expected to grow in the UK as more people chose to live alone. The housing blocks catered for a single person habitation should be highly energy efficient equipped with highly energy efficient appliances to minimise the CO_2 emissions arising from this group of population.

A brief inventory of heating systems and household appliances of this sample of healthcare professionals showed that some participants could benefit from upgrading the old boiler and fridges and freezers to a more energy efficient type that could save both money and CO_2 emissions. The uptake rate of double glazing was higher compared to that of cost effective measures such as energy saving light bulbs and draught proofing possibly due to the extra benefits of security and safety which are more important priorities to households than energy saving.

In general, survey participants had very little awareness of how much energy they were using and what kind of heating systems they had etc. Energy conservation is still a low priority for the majority of households and there is a lack of motivation to improve energy efficiency standards of their homes. This is possibly due to the poor billing information and the method of payment selected that many households do not check utility bills especially those using the direct debit payment method. Altering the payment method of energy e.g. pay as you go, may be able to help some consumers to increase sensitivity towards energy consumption. The little awareness of energy usage is also partly explained by the relatively low cost energy in proportion to the total household income especially amongst the doctors.

The questionnaire included several other questions such as the insulation thickness around the hot water cylinder, the energy efficiency rating of cold appliances etc, but only a handful of participants were able to answer these questions which exhibited the little awareness of energy conservation by participants.

Chapter 6: CO_2 emissions from personal car travel

This chapter analyses CO_2 emissions associated with personal car use and the impact of personal car travel habits. The possible savings in CO_2 emissions through changing travel methods are also explored.

6.1 Car ownership

Figure 6.1.1 shows the number of cars owned by survey participants as a household. 31 out of 37 participants (84%) own at least one car and 13 participants own more than one car. Table 6.1.1 shows the number of cars owned by participants of different household types. It shows that as the number of household members increases, people tend to own more cars. e.g. couples and families. (Note: The participants who lived in "Flat share" households only provided their own car information.)

Figure 6.1.1 No. of cars owned by participants

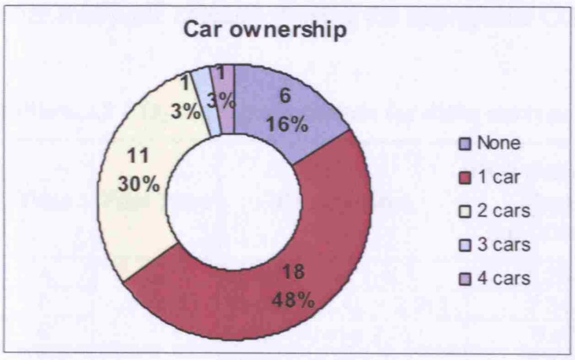


Table 6.1.1 Car ownership by household type

Household type\ No. of cars owned	Single	Couple	Family	Flat share	Total
0	1	1	3	1	6
1	8	5	0	5	18
2	0	7	4	0	11
3	0	0	1	0	1
4	0	0	1	0	1
Total	9	13	9	6	37

6.2 CO_2 emissions Calculation

In order to calculate CO_2 emissions from car travel, cars were categorised based on the type of fuel and the size of engine to determine the appropriate CO_2 conversion factor for each car type. (See Table 7.2.1) "Type B" car with the engine size of 1.4 to 2.0 litres engine and petrol fuel was the most popular car type owned by the survey participants. Annual CO_2 emissions from each car were calculated by multiplying the annual mileage and the CO_2 conversion factor. For those households that own multiple numbers of cars, CO_2 emissions from each car were added together to determine the total household CO_2 emissions from all the cars that owned. The annual household car CO_2 emissions were divided by the number of people in the house aged 17 years old or above to determine the annual CO_2 emissions per person from their shared use of cars. This allocation method was applied to all household groups except "flat share" because the participants from this household group only provided their own car information and not of other household members. Table 6.2.2 shows CO_2 emissions associated with all cars owned by the participants. There was one participant who owned a small motorcycle and CO^2 emissions were calculated using the appropriate CO_2 conversion factor provided by DEFRA.[36]

Table 6.2.1 CO_2 conversion factors for different type of cars (Source: Defra)[37]

Type	Fuel Type	Engine Size	CO2 Conversion Factor (kg CO2/mile)	CO2 Conversion Factor (kg CO2/km)	No. of Cars
A	Petrol	Small (Up to 1.4L)	0.2947	0.1831	14
B		Medium (1.4L ~ 2.0L)	0.3479	0.2162	24
C		Large (Above 2.0L)	0.477	0.2964	4
D	Diesel	Small (Up to 1.7L)	0.2425	0.1507	0
E		Medium (1.7 ~ 2.0L)	0.3027	0.1881	4
F		Large (Above 2.0L)	0.424	0.2675	1

[36] 0.1174 CO_2 kg /mile used. Source: Guidelines to Defra's GHG conversion factors for company reporting, June 2007, Defra

[37] Guidelines to Defra's GHG conversion factors for company reporting, June 2007, Defra

Table 6.2.2 CO_2 emissions from all cars including car rental & other vehicle

ID number	Household Type	No. of people in house	No. of people aged over 17	Car 1 CO2 Emissions (kg)	Car 2 CO2 Emissions (kg)	Car 3 CO2 Emissions (kg)	Car 4 CO2 Emission (kg)	Car rental CO2 emissions (kg)	Other vehicle CO2 emissions (kg)	Total CO2 emissions (kg)	Individual CO2 emissions (kg)
D15	Flat share	2	1	0	0					0	0
N10	Family	4	3	0	0					0	0
N3	Single	1	1							0	0
N7	Family	4	2	0	0					0	0
N8	Family	4	2	0	0					0	0
D16	Couple	2	2		0			2,400		835	417
O3	Family	3	3	678	678					1,356	452
N4	Couple	2	2	1,740	0					1,740	870
N5	Single	1	1	1,474	0					1,474	1,474
P1	Couple	2	2	2,783	0				365	3,148	1,574
N2	Family	4	2	3,027	354					3,381	1,690
D20	Couple	2	2	3,479	0					3,479	1,740
D3	Family	3	2	2,783	696					3,479	1,740
D5	Single	1	1	1,740	0					1,740	1,740
D7	Single	1	1	1,740	0					1,740	1,740
D19	Single	1	1	1,740	0					1,740	1,740
D1	Couple	2	2	3,479	0					3,479	1,740
D12	Flat share	5	1	1,768	0					1,768	1,768
D14	Flat share	2	1	1,916	0					1,916	1,916
D13	Couple	2	2	2,087	1,768					3,856	1,928
D4	Single	1	1	2,087	0					2,087	2,087
N11	Flat share	3	1	2,358	0					2,358	2,358
P2	Flat share	4	1	2,358	0					2,358	2,358
D17	Single	1	1	2,422	0					2,422	2,422
D9	Family	4	2	3,479	2,385					5,864	2,932
O2	Couple	2	2	2,783	3,536					6,320	3,160
N9	Couple	2	2	2,947	3,479					6,426	3,213
N1	Family	3	3	2,358	5,088	1,740	1,044			10,229	3,410
D11	Flat share	2	1	3,479	0					3,479	3,479
D10	Single	1	1	3,479	0					3,479	3,479
D2	Couple	2	2	2,947	4,175					7,122	3,561
O1	Couple	2	2	8,841	0					8,841	4,421
D18	Family	4	2	5,219	2,435	1,272				8,926	4,463
N6	Couple	2	2	5,894	3,479					9,373	4,687
D8	Single	1	1	5,724	0					5,724	5,724
D6	Couple	2	2	8,586	3,816					12,402	6,201
O4	Couple	2	2	5,219	9,081					14,300	7,150

Figure 6.2.1 shows the sum of annual car mileage for all cars owned by each household for all participants. The total annual household car mileage varied greatly among households that it ranged from 2,500 miles to 45,000 miles per household and the average car mileage per household was 13,575 miles. The allocated annual car mileage per person (the same allocation method was used as above) ranged from 0 miles to 22,500 miles and the average was 7,024 miles. Figure 6.2.2 shows the annual allocated CO_2 emissions and car mileage per person. The individual CO_2 emissions (per person) ranged from 0 kg to 7.2 tonnes and the average CO_2 emissions were 2.4 tonnes.

It can be noted that the overall CO_2 emissions were also affected by the choice of vehicles. For instance, O1 and N6 travel more than D6 and D8, however, D6 and D8 have large car engines (above 2.0 litres) resulting in higher CO_2 emissions despite less distances travelled.

Figure 6.2.1 Annual household car mileage and the individual mileage allocation

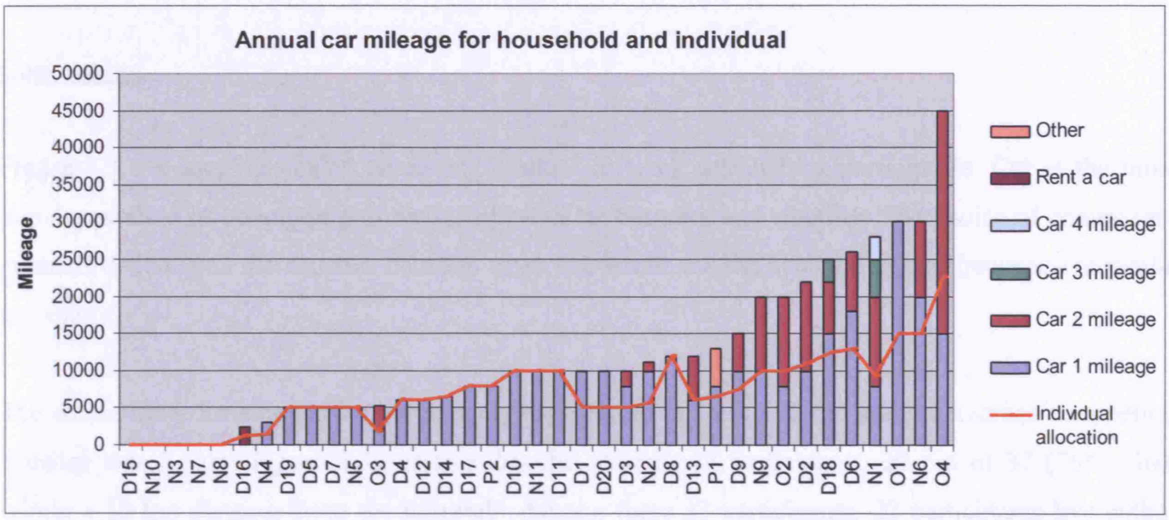
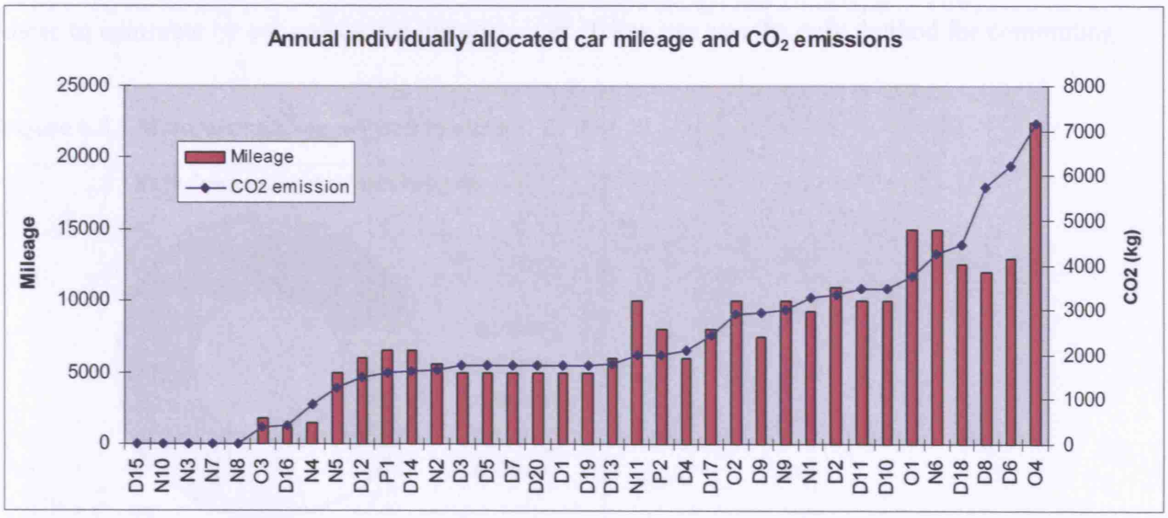


Figure 6.2.2 Annual individually allocated car mileage and CO_2 emissions



6. 3 Travel patterns

Commuting

Figure 6.3.1 shows the main commuting method to work selected by participants. Car is the most popular method of commuting to work, followed by bus/tram and walking. The choice of commuting methods depends on the distance between work and home and the availability and frequency of public transport.

The commuting distance for the participants varied from 100 m to 35 km and the average commuting distance was 8.5km. Figure 6.3.2 shows that the majority of participants, 29 out of 37 (78%), live within a 10 km distance from the hospital. Among these 33 participants, 22 participants live within 5km from the hospital and 7 participants live in a 5 to 10km distance from the hospital. For the distance less than 2km from the work, people chose to walk or cycle. From 2km onwards, some participants chose to commute by car and for the distance over 10 km, car was the only method for commuting.

Figure 6.3.1 Main commuting method to work

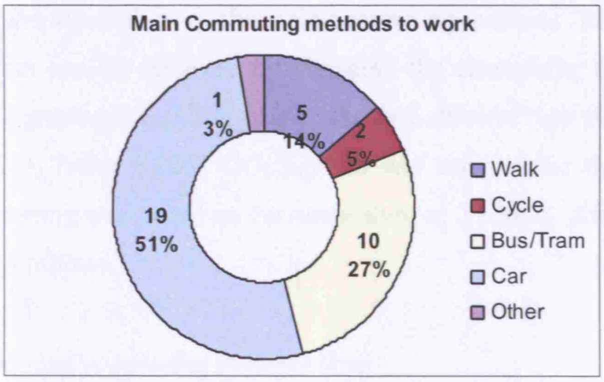
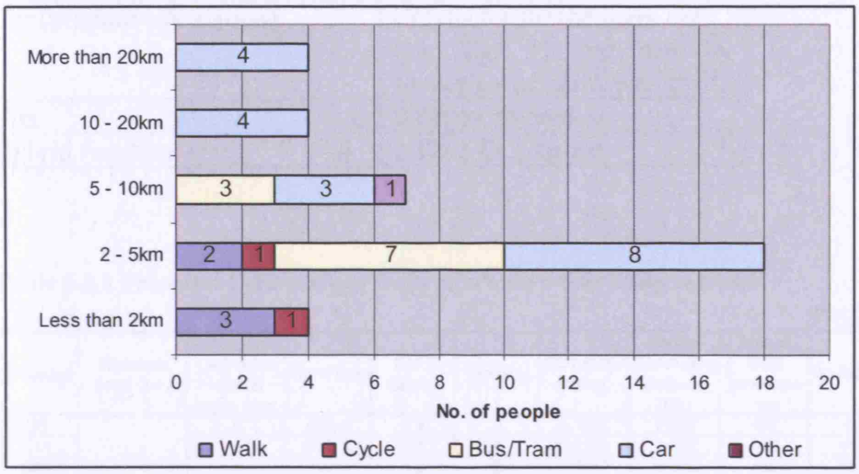


Figure 6.3.2 Commuting method and distance between work and home



The alternatives to car commuting include walking, cycling and public transport. For those do not have the access to public transport, CO_2 emissions can be reduced by car sharing (or car pooling) [38] or upgrading the car to the fuel efficient type.

Table 6.3.1 shows the estimate of annual CO_2 emissions due to commuting by car for those participants who selected car as the main commuting method. The table also shows potential CO_2 emissions savings that can be achieved by changing the commuting method from car to walking/cycling, taking bus, upgrading the existing car to the fuel efficient type and car sharing. A medium size hybrid car with the CO_2 factor 0.1262 CO_2 kg/ km was selected for the fuel efficient car type as an example and car sharing was based on car occupancy of 2 people. Annual car commuting CO_2 emissions were derived as follows.

Annual commuting distance (km)

= Distance between work & home (km) x 2 journeys x 5 days x 52 weeks

Annual CO_2 emissions due to commuting (kg)

*= Annual commuting distance (km) x CO_2 conversion factor**

[38] Car sharing is shared use of a car, in particular for commuting to work, often by people who each have a car but travel together to save costs and in the interest of other socio-environmental benefits such as reduction in air pollution and CO2 emissions. http://en.wikipedia.org/wiki/Carpooling

*Note: The following CO_2 factors were used for each calculation.[39]

Car (original calculation)	CO_2 factor for the main car (i.e. Car 1) provided by survey participants was used.
Bus	0.0891 CO_2 kg/km
Hybrid (medium size)	0.1262 CO_2 kg/km

Table 6.3.1 Potential CO2 savings from alternative travelling methods

ID number	Distance band (km)	Distance between work & home (km)	Car 1 Fuel	Car 1 Engine	Car type	CO2 factor (kg/km)	Annual commuting distance (km)	Annual CO2 emissions (kg)	CO2 savings from alternative methods: Walk/Cycle	Bus	Fuel efficient car	Car sharing
N5	2 to 5	5	Petrol	1.4	A	0.1831	2,600	476	476	244	148	238
D11		4	Petrol	1.6	B	0.2162	2,080	450	450	264	187	225
D19		4	Petrol	1.6	B	0.2162	2,080	450	450	264	187	225
D4		5	Petrol	1.6	B	0.2162	2,600	562	562	330	234	281
02		5	Petrol	1.6	B	0.2162	2,600	562	562	330	234	281
D7		2	Petrol	1.8	B	0.2162	1,040	225	225	132	94	112
D13		2	Petrol	2	B	0.2162	1,040	225	225	132	94	112
D8		2	Petrol	2.2	C	0.2964	1,040	308	308	216	177	154
N4	5 to 10	9.6	Petrol	1.6	B	0.2162	4,992	1,079		634	449	540
D9		6	Petrol	1.8	B	0.2162	3,120	675		397	281	337
D3		8	Petrol	2	B	0.2162	4,160	899		529	374	450
N9	10 to 20	14.4	Petrol	0.9	A	0.1831	7,488	1,371			426	686
03		13	Petrol	1	A	0.1831	6,760	1,238			385	619
N1		16	Petrol	1	A	0.1831	8,320	1,523			473	762
01		19	Petrol	1.3	A	0.1831	9,880	1,809			562	905
D17	More than 20	29	Diesel	1.8	E	0.1881	15,080	2,837			933	1,418
N2		32	Diesel	1.9	E	0.1881	16,640	3,130			1,030	1,565
N6		28.8	Petrol	1.4	A	0.1831	14,976	2,742			852	1,371
D6		35	Petrol	3	C	0.2964	18,200	5,394			3,098	2,697

For those participants live within a 5km distance from the hospital, walking or cycling would be the best alternatives to achieve maximum CO_2 emissions saving. Annual CO_2 saving can also be achieved by using bus (132kg ~ 330kg per person) and car sharing (112kg ~ 238kg per person). For those live far away from the work place, changing the existing car to the more fuel efficient type would be the most effective way of reducing CO_2 emissions. Car sharing can also achieve large reduction in CO_2 emissions, but the availability of car sharing partners can be problematic.

Several alternative options other than car are available for those living closer to the work, however, work schedules, habits, weather, convenience etc prevent people from switching a commuting method from car to more sustainable methods.

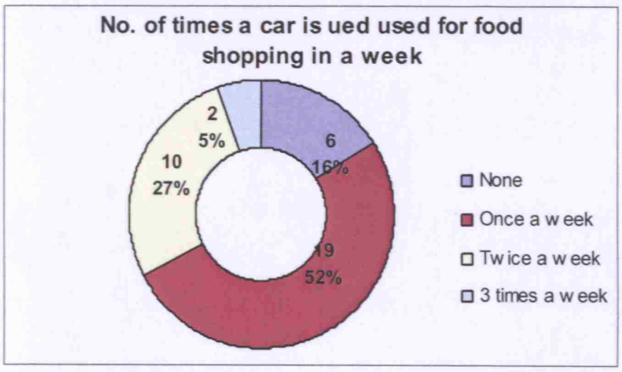
[39] Guidelines to Defra's GHG conversion factors for company reporting, June 2007, DEFRA

Shopping

Figure 6.3.3 shows the number of times participants use a car for their food shopping in a week. 31 out of 37 participants (84%) use a car for their food shopping at least once a week. The distance between home and a food store travelled by car ranged from 1 km to 25 km among the participants and the average distance was 4.6km. There are approximately 24.2 million households in the UK.[40] Assuming that every household in the UK travels 9.2km (4.6km x 2 journeys) by car for food shopping once a week, this would lead to 2.5 millions tonnes of CO_2 emissions per year.

9.2 km x 0.2162 CO_2 kg/km x 52weeks x 24.2 mm households = 2.5 million tonnes
(Note: CO_2 factor for Car type B was used for this estimation.)

Figure 6.3.3 Frequency of car use for food shopping



CO_2 emissions from short car journeys that people make in their everyday life accumulate to a significant amount of carbon dioxide emissions at the national level. In other words, small changes in personal travel habits could potentially achieve large CO_2 emissions reduction.

6.4 Discussion

The total annual CO_2 emissions associated with personal car use for the cohort of healthcare professionals were 87.6 tonnes and the average emissions were 2.4 tonnes per person. A high level of car usage by the sample population can be related to the location where the survey was undertaken. The

[40] Social Trends, No 37 2007 edition, Office for National Statistics, Available at http://www.statistics.gov.uk/downloads/theme_social/Social_Trends37/Social_Trends_37.pdf

level of car ownership is highly dependent on traffic congestion and the availability of public transport in the relevant location .e.g. The car ownership rate is lower in Central London due to heavy traffic and the extensive public transport network.

Potentially large CO_2 emissions saving can be made by changing travel habits such as commuting and shopping. However, at present, conveniences offered by cars are so valued that high costs of petrol and traffic congestion do not deter people from driving. Although car sharing could be a potentially suitable alternative amongst the doctors living nearby, many participants listed "different working schedule", "inconvenience", "reliability" as the main obstacles to implementation of such programme. Most people rely on cars for grocery and other household shopping. A change in shopping styles e.g. internet shopping for bulky household items and food shopping by foot at local stores, could be explored at the community level.

Chapter 7: CO_2 emissions from Flights

This chapter analyses CO_2 emissions associated with flights. Personal flying patterns based on professional types are also reviewed.

7.1 CO_2 emissions calculation

CO_2 emissions from flights were calculated by multiplying the distance travelled and the appropriate CO_2 conversion factor (i.e. short haul/long haul) provided by DEFRA. Figure 7.1.1 shows the CO_2 emissions from flights including both business and holiday travels. The yellow dotted line in the graph shows the total CO_2 emissions (for business and holiday travels) calculated inclusive the impact of radiative forcing (i.e. Non-CO_2 climate impact). A wide variation in individual CO_2 emissions from flights was observed that they ranged from 0 kg to 7.2 tonne per person. (See Table 7.1.1) The average CO_2 emissions from flights were 2.4 tonnes per person (exclusive of the radiative forcing impact)

Figure 7.1.1 CO2 emissions from flights (Business & Holiday)

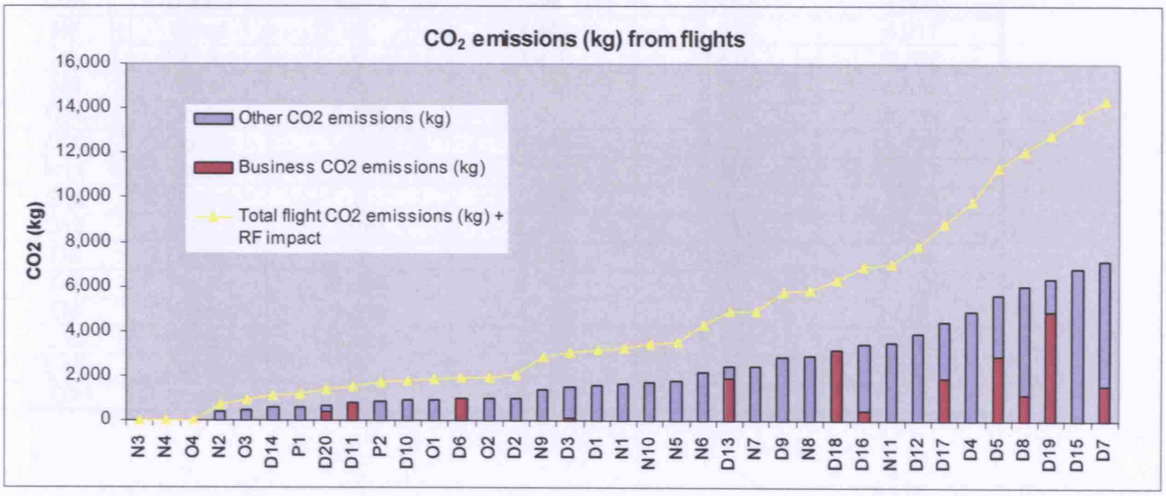


Table 7.1.1 CO_2 emissions from flights (Business & Holiday)

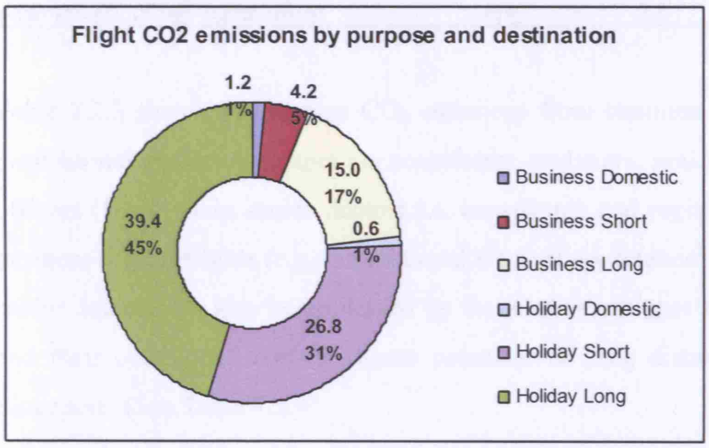
ID number	Profession	Business CO2 emissions (kg)	Other CO2 emissions (kg)	Total flight CO2 emissions (kg)	Total flight CO2 emissions (kg) + RF impact
N3	Other	0	0	0	0
N4	Other	0	0	0	0
O4	Other	0	0	0	0
N2	Other	0	372	372	744
O3	Other	0	457	457	914
D14	Doctor	0	568	568	1,137
P1	Other	0	614	614	1,228
D20	Doctor	381	307	688	1,375
D11	Doctor	768	0	768	1,536
P2	Other	0	854	854	1,707
D10	Doctor	0	907	907	1,813
O1	Other	0	935	935	1,869
D6	Doctor	964	0	964	1,927
O2	Other	0	966	966	1,932
D2	Doctor	0	1,015	1,015	2,029
N9	Other	0	1,426	1,426	2,851
D3	Doctor	105	1,421	1,526	3,053
D1	Doctor	0	1,599	1,599	3,198
N1	Other	0	1,629	1,629	3,258
N10	Other	0	1,735	1,735	3,470
N5	Other	0	1,762	1,762	3,523
N6	Other	0	2,166	2,166	4,331
D13	Doctor	1,949	504	2,452	4,905
N7	Other	0	2,459	2,459	4,917
D9	Doctor	0	2,876	2,876	5,752
N8	Other	0	2,936	2,936	5,871
D18	Doctor	3,166	0	3,166	6,332
D16	Doctor	450	3,010	3,461	6,921
N11	Other	0	3,508	3,508	7,017
D12	Doctor	0	3,916	3,916	7,833
D17	Doctor	1,941	2,477	4,418	8,837
D4	Doctor	0	4,905	4,905	9,810
D5	Doctor	2,894	2,767	5,661	11,322
D8	Doctor	1,206	4,833	6,040	12,079
D19	Doctor	4,934	1,466	6,400	12,800
D15	Doctor	0	6,817	6,817	13,634
D7	Doctor	1,600	5,577	7,177	14,355

7.2 Flight patterns

Purpose and Destinations

Figure 7.2.1 shows the total amount of carbon dioxide emitted (87.1 tonnes) by this survey population taking flights in the past year and CO_2 emissions were categorised by purpose (business/holiday) and destination (domestic/short/long). Short flights included most European destinations (i.e. a flight distance less than 3,500km) and long haul flights included far-away destinations (i.e. a flight distance more than 3,500 km) such as North America, Asia and Africa etc. "Domestic" flights included any UK destinations. e.g. Edinburgh. More than three quarters of CO_2 emissions were associated with holiday flights.

Figure 7.2.1 Flight CO2 emissions by purpose and destination



Flight patterns by professional type

Table 7.2.1 shows the average CO_2 emissions from business and other flights for the doctors and other healthcare professionals including nurses, occupational therapists and physio therapists. The average CO_2 emissions from other flights (holiday) were 2.6 tonnes for doctors and 1.6 tonnes for other professionals. Table 8.2.2 shows the average number of flights taken for both business and other purposes (holiday) for doctors and other professionals. One single flight regardless of the distance travelled was counted as "one flight" and so one return flight consists of two flights. The average number of flights taken by the doctors for other purposes was 6.2 per person, just over 3 return flights and the average number of flights taken by other professionals was 2.8 per person, just over one return flight. On average, the doctors travel more often than other healthcare professionals.

Table 7.2.1 Average CO_2 emissions for doctors and other healthcare professionals

	Doctor	Other	All
No. of responses	20	17	37
Average CO2 emissions (kg) from Business Flights	1,697		1,697
Average CO2 emissions (kg) from Other Flights	2,645	1,558	2,154
Average CO2 emissions (kg) from All Flights	3,266	1,283	2,355

Table 7.2.2 Average number of flights taken by doctors and other healthcare professionals

	Doctor	Other	Total
No. of responses	20	17	37
Average no. of Business Flights taken	3.2	0.0	1.7
Average no. of Other Flights taken	6.2	2.8	4.6
Average no. of All Flights taken	9.4	2.8	6.4

Table 7.2.3 shows the average CO_2 emissions from business and other flights (holiday) for different professional grades of doctors i.e. consultants, registrars, senior house officers (SHO) and junior house officers (JHO). Only senior doctors i.e. consultants and registrars had CO_2 emissions associated with business related flights (e.g. international medical conferences). Higher CO_2 emissions associated with senior doctors can also be explained by the relatively higher ratio of foreign nationals in these grades and their occasional visits to home countries of long distance away from the UK. e.g. Malaysia, Singapore. (See Table 7.2.4)

Table 7.2.3 Average CO2 emissions for different professional grades of doctors

	Professional Grades				
	Consultant	**Registrar**	**SHO**	**JHO**	**All**
No. of responses	4	9	3	4	20
Average CO2 emissions from Business Flights	2,812	1,139			1,697
Average CO2 emissions from Other Flights	2,925	2,352	1,173	4,052	2,645
Average CO2 emissions from All Flights	5,006	2,841	1,173	4,052	3,266

Table 7.2.4 Ratio of foreign professionals for each profession type

	Doctors				Other			
Nationality	Consultant	Registrar	SHO	JHO	Nurse	OT	PT	All
UK	1	4	3	3	7	4	2	24
Non UK	3	5		1	4			13
Total	4	9	3	4	11	4	2	37
% of Non UK origin	75%	56%	0%	25%	36%	0%	0%	35%

7.3 Discussion

The total CO_2 emissions from flights taken by this sample population in the last year were 87.1 tonnes (2.4 tonnes per person). If the radiative forcing impact (i.e non-CO_2 climate impact) was to be included in CO_2 emissions estimation, this figure would double to 174 tonnes (4.7 tonnes per person). In general, doctors flew more than other healthcare professionals even removing business related flights for comparison. This could be related to the different level of disposable income among different healthcare professional types and grades. The individuals with higher disposable income tend to consume more leisure activities such as holiday in abroad which result in higher CO_2 emissions.

Air travel currently accounts for 6.3 % of total UK CO_2 emissions and it is projected to increase to a quarter by 2030. [41] It is the fastest growing sector contributing to CO_2 emissions and perhaps the most challenging sector to control as people are aspired to travel and the demand for air travel increases as the economy grows. A recent study suggests that higher taxation on flights is unlikely to curb the growing CO_2 emissions from aviation as the frequent flyers are likely to absorb the higher costs of flying, but not to fly less. [42] Where the application of fiscal measure is ineffective, personal carbon allowance on flying could be a possible solution to set the limit on how many flights each individual is entitled to.

[41] http://www.direct.gov.uk/en/Environmentandgreenerliving/Greenertravel/DG_064429
[42] http://news.bbc.co.uk/2/hi/science/nature/6311603.stm

Chapter 8: Semi-structured interviews

The questionnaire included a series of questions concerned with personal energy consumption behaviours and attitudes towards the environmental problems. These questions were used as a framework for the semi-structured interviews. This chapter reviews the survey responses obtained from the participants on the following questions in particular.

1. Has an individual taken any actions to reduce his/her CO_2 emissions? If so, what actions has he/she taken?
2. Does an individual think he/she can reduce more emissions? If so, what is he/she going to do?
3. Are there any barriers that prevent an individual to reduce his/her CO_2 emissions?
4. What government legislation does an individual support to reduce CO_2 emissions at the national level?
5. What does an individual think the fair price for 1 tonne of CO_2 emissions?

8.1 Question 1

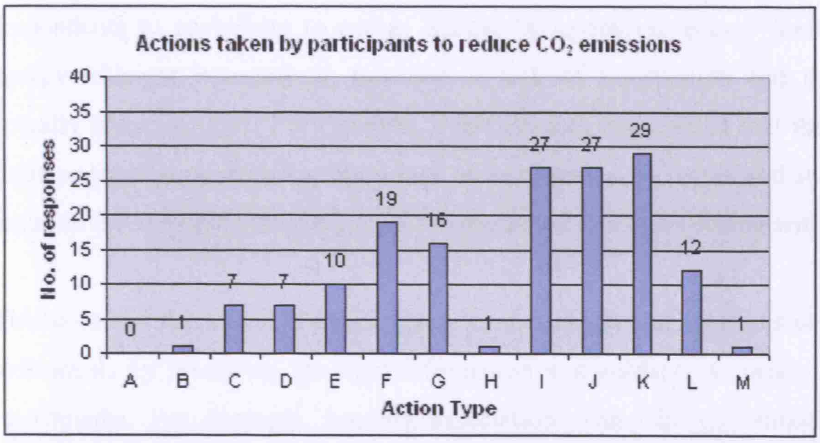
- If you have you taken any actions to reduce your CO_2 emissions recently, please tick the appropriate boxes.

  1. I installed solar panel or wind turbine or heat pump etc in my house. □
  2. I changed my car to the fuel efficient car. □
  3. I have upgraded my fridge/freezer/fridge freezer combined to the more energy efficient type. □
  4. I have upgraded my boiler to the more energy efficient type (e.g. combi boiler). □
  5. I have installed loft insulation/wall insulation/double glazing. □
  6. I changed the light bulbs to energy efficient light bulbs. □
  7. I now walk and cycle more. □
  8. I reduced the number of flights I take. □
  9. I don't leave the equipments (e.g. TV, computers, stereos etc) on stand by when I don't use. □
  10. When I use a kettle, I only boil the water I need to use. □
  11. I switch off lights when they are not in use. □
  12. I buy groceries from local regions closer to the UK to reduce my food miles. □
  13. Other. (   )

The question was devised to observe if participants have taken any actions to reduce CO_2 emissions and if so, what kind of actions they have taken. In order to assist the participants, a series of actions from simple behavioural changes to large scale energy efficiency investments were listed to allow them pick the appropriate ones.

The majority of participants have taken some kind of actions to reduce their personal CO_2 emissions. A caution has to be taken when analysing this data as this was based on their personal self-assessment. Figure 8.1.1 shows the number of responses given by participants for different type of actions to reduce CO_2 emissions.

Figure 8.1.1 Actions taken by participants to reduce CO_2 emissions



Type	Action description	
A	Installed solar panel/ wind tubine/ heat pump	Energy efficiency investment
B	Upgrade car to fuel efficient type	
C	Upgraded fridge freezer to energy efficient type	
D	Upgraded boiler to energy efficient type	
E	Installed loft insulation/wall insulation/double glazing	
F	Installed energy efficient lightbulbs	Behavioural Change
G	Walk & cycle more	
H	Reduced no. of flights	
I	Don't leave equipment on stand by when not in use	
J	Kettle - only boil the required water	
K	Switch off lights when not in use	
L	Buy local produce to reduce food miles	
M	Other	

From the graph, it can be seen that more participants have undertaken simple behavioural changes such as "switching off lights when they are not in use", "do not leave the equipments on stand by", "only boil the required amount of water" etc than energy efficiency investments. A large number of responses for these behavioural changes could be related to the recent government's campaigns to promote energy conservation and the extensive media coverage on these topics.[43] [44] Whether or not people actually insist these energy conservation habits at home is unknown, however, this exercise revealed that the majority of participants were aware of these behavioural changes could contribute to energy saving and CO_2 emissions reduction. One nurse commented that her children insisted switching off lights and not to leave the TVs on stand by at home and this has led to the behavioural change of other family members. This demonstrates that education on energy and water conservation at schools could help to change energy inefficient behaviours of adults through the web of family network.

The feedback from the survey participants revealed that there was a high willingness among the respondents to contribute to energy saving by upgrading energy inefficient appliances and making energy efficient investments, however, a lack of information and time prevent many individuals actually taking actions. For example, a few doctors commented that they were interested in installing solar water heating systems, but a lack of information on prices and suppliers and the perceived time required for arranging building work etc prevented them proceeding with actions.

This could be the potential areas where local councils and boroughs could take the initiative to assist individuals by providing the right information and guidance to make the adequate energy efficiency investments. For example, housing associations can take the initiative in coordinating collective upgrade of outdated energy inefficient boilers or appliances for all residents in the same housing block. A much larger scale of energy efficiency improvements can be achieved systematically. A careful balance needs to be achieved between giving personal choice according to the individuals' financial circumstances and assisting individuals by removing anxiety e.g. time, efforts associated with coordinating medium to large scale energy efficiency investments.

9.2 Question 2

- This questionnaire involved an exercise of reviewing your personal carbon footprint. Do you think more can be done to reduce your personal emissions? (Yes/No)
- If "Yes", what would you do to reduce your emissions?

---

[43] http://www.energysavingtrust.org.uk/

[44] http://www.telegraph.co.uk/portal/main.jhtml?view=CAMPAIGN&grid=P9&pg=/ETHtml/content/promotions/2005/10/25/saveyour20percent.jhtml&pc=saveyour20percent

32 out of 37 participants (87%) answered that they could reduce more emissions. With regards to a question what they would do to cut down their CO_2 emissions, "drive less", "walk and cycle more", "buy energy efficient appliances", "replace existing light bulbs with the energy efficient ones", "recycle more" were common responses. Three doctors commented changing flying patterns by reducing the number of flights they take and seeking alternative ways of traveling other than flying.

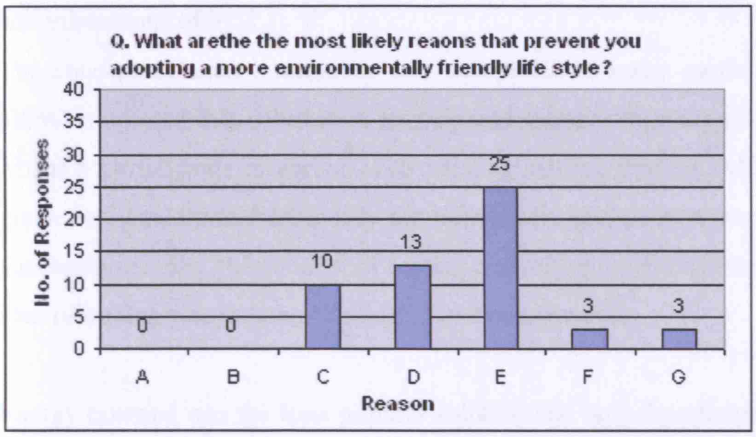
8.3. Question 3

- Reducing the individual CO_2 emissions can be challenging. Please tick the appropriate reasons that prevent you adopting a more environmentally friendly lifestyle.

1. I don't believe in the climate change and I don't feel the need to reduce my emission. □
2. The damage has already been done and I don't see any point in taking any actions. □
3. I don't know how much emissions I am currently causing and I never had any urge to do something about it. □
4. I care about the environment, but I am not prepared to give up my current life style. □
5. There is a lack of support by the government to assist the general public to lead the more environmentally friendly life style. □
6. My lifestyle is low carbon intensive and I feel that I have already done my part. □
7. Other □ ( )

Figure 8.3.1 shows the reasons selected by participants that prevent them adopting a more environmentally friendly lifestyle. (A table below shows the description of each reason.) "A lack of support from the government" was the most popular reason given by the participants. Many participants expressed dissatisfaction with the insufficient provision of recycling facilities and services and poor billing information regarding household energy consumption. Other common reasons included "unwillingness to give up current life style" and "a lack of knowledge on personal emissions". "A lack of time", "habits" and "ignorance" were given as "Other" reasons.

Figure 8.3.1 Barriers to prevent adopting a more environmentally friendly life style



Reason	Description
A	I don't believe in the climate change and I don't feel the need to reduce my emissions.
B	The damage has already been done and I don't see any point in taking any actions.
C	I don't know how much CO2 emissions I am emitting and I never had any urge to do something about it.
D	I care about the environment, but I am not prepared to give up my current life style.
E	There is a lack of support by the government to assist the general public to lead the more environmentally friendly life style.
F	My life is low carbon intensive and I feel that I have already done my part.
G	Other

8.4 Question 4

- Many people feel that the government should be doing more to reduce carbon emissions on a national level. If the government were to take a more active role, which of the following do you support?

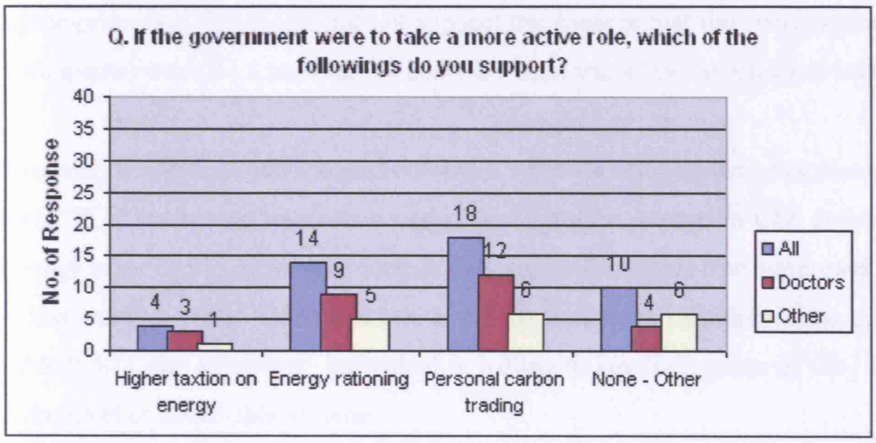
  1. Higher taxation on energy
  2. Energy rationing (Enforced ceiling limits on personal carbon emissions)
  3. Personal carbon trading
  4. None of the above. Please specify if you have any other ideas.

This question was devised to observe what government legislation the individuals would support. The participants were allowed to choose more than one solution and the detailed explanations of each solution were given during the interviews. Figure 8.4.1 shows the responses given by the participants. Personal carbon trading (PCT) was the most popular solution in this survey that 18 out of 37 participants (49%) supported this solution. The reasons for supporting PCT included flexibility and fairness. However, a number of participants expressed doubts regarding technical feasibility and administrations of PCT.

The concept of energy rationing was acceptable to many participants that 14 out of 37 participants (38%) supported this solution. 6 participants chose both energy rationing and personal carbon trading whilst 8 participants disagreed with personal carbon trading. Although the trading feature in PCT is given as the additional capability for individuals who need or want to emit more are able to do so by purchasing credits, the concept of buying and selling credits did not appeal to some participants that the idea of trading was rather complicated and cumbersome.

Energy taxation was the least popular solution that only 4 participants supported this solution. Those in favour of taxation argued that taxation was fair, transparent and effective. Those objected taxation were skeptical about how the revenues raised from taxation would be used. A number of participants also complained that there were too many taxes in the UK. Those who did not choose any of suggested solutions commented that industries should take more responsibilities and more help should be given by local councils etc in the form of education and information.

Figure 8.4.1 Possible solutions selected by the participants



8.5 Question 5

- What do you think would be the fair price for a tonne of CO_2 emissions in the context of personal carbon trading? FYI – A tonne of CO_2 is equivalent to the amount of CO_2 emissions from a single flight from London to Mumbai per passenger. *(Source: www.climatecare.org)*

1. £5
2. £10
3. £20
4. £50
5. £100
6. £200
7. £500

This question was devised to observe how people would decide the price for 1 tonne of carbon dioxide emissions. The estimated CO_2 emissions from a single flight from London to Mumbai were provided to assist the participants to have an approximate idea of how much 1 tonne of CO_2 emissions relate to.[45]

Figure 8.5.1 shows a range of prices selected by the participants for 1 tonne of CO_2 emissions. As the graph shows, what people think "the fair price for a tonne of CO2 emissions" varied greatly among the cohort interviewed. It was observed that those who agreed with PCT concept were willing to pay higher price than those who did not support the concept that the average price for PCT supporters (18 participants) was £74.7 and that for non-PCT supporters (19 participants) was £21.3. (See Table 8.5.1)

However, it was also noted that there was a wide variation in the price chosen by the PCT supporters. Most "PCT supporting" doctors chose £50 or more for a tonne of CO_2 emissions which resulted in the average price of £93.3. Among other healthcare professionals who supported PCT, 4 out of 6 chose £10 or less and two chose £100 for a tonne of CO_2 emissions, resulting in the average price of £37.5. (See Table 9.5.1) The amount an individual is willing to pay for a tonne of CO_2 emissions is highly related to the level of disposable income.

A number of participants commented that how much they were prepared to pay for 1 tonne of CO_2 emissions depended on how much carbon credits they had to buy in order to sustain their current life style. Due to a limited knowledge of CO_2 emissions associated with their personal energy consumption such as gas, electricity and car use, most participants were unable to make the informed decision in determining the price of CO_2 emissions. Although an example of the estimated CO_2 emissions from a

[45] http://www.climatecare.co.uk

flight was given, this was not clear enough for many participants to estimate the amount of CO_2 emissions they were responsible for. If the participants were given their estimated CO_2 emissions from the survey results, the answers could have been different. This demonstrates that the application of PCT could help people think energy consumption in terms of carbon usage. This "carbon literacy" is a new skill required to budget carbon emissions which can be enforced by personal carbon trading and this could increase individual's sensitivity towards energy consumption and reduce CO_2 emissions at the personal level.

Figure 8.5.1 Survey responses for the price of 1 tonne of CO_2

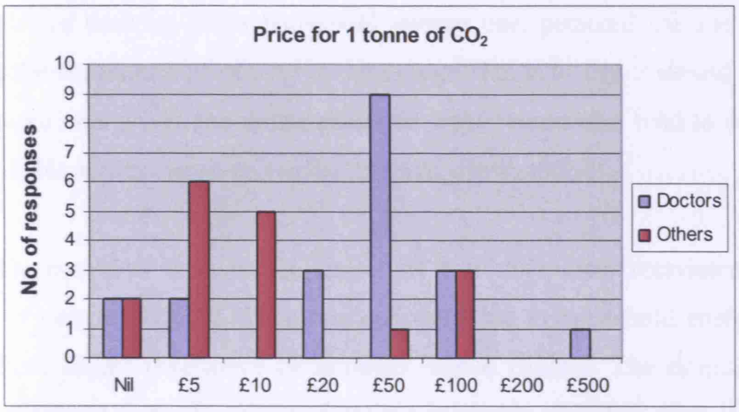


Table 8.5.1 Price for 1 tonne of CO2 emissions selected by PCT supporters and Non-PCT supporters

Support PCT				Do not support PCT			
ID number	Doctor	Other	All	ID number	Doctor	Other	All
No. of responses	12	6	18	No. of responses	8	11	19
N10		5	5	D15	0		0
N4		5	5	D5	0		0
O4		5	5	N2		0	0
O1		10	10	N3		0	0
D7	20		20	D6	5		5
D19	50		50	N11		5	5
D20	50		50	D18	5		5
D3	50		50	N7		5	5
D4	50		50	O2		5	5
D14	50		50	N9		10	10
D1	50		50	N1		10	10
D11	50		50	P1		10	10
D12	50		50	P2		10	10
D2	100		100	D9	20		20
N6		100	100	D10	20		20
O3		100	100	D8	50		50
D16	100		100	N5		50	50
D13	500		500	N8		100	100
				D17	100		100
Average price	93.3	37.5	74.7	Average price	25.0	18.6	21.3

Chapter 9: Conclusion

This thesis investigated personal carbon dioxide emissions using a case study sample of healthcare professionals. Participants were interviewed using a questionnaire to collect data on energy consumption. The data obtained was then used to calculate CO_2 emissions from household energy use, car travel and flights and construct a personal energy consumption profile for each individual interviewed. This method proved to be a viable and reproducible approach to calculating visible domestic energy consumption; less visible sources of energy consumption such as work-related consumption is beyond the scope of the questionnaire, and thesis. However, a combined CO_2 emissions picture drawing from household energy use, personal car use and flights (Table 9.1.1) provides a coherent picture of general carbon usage, that is to say, it should hold true that someone who consumes more energy via the aforementioned ways would also tend to consume more energy through the less visible routes (work-related or material consumption).

The combined annual CO_2 emissions from the cohort interviewed was 245 tonnes (roughly 6.6 tonnes per person) 37% of CO_2 emissions were due to household energy use, 36% from car travel and 27% from flights (exclusive of business related flights). The estimated CO_2 emissions from flights were calculated from conversion factors provided by DEFRA. This is thought to provide a modest estimate of CO_2 emissions as the impact of radiative forcing from flights (i.e. Non – CO_2 climate impact) was not taken into account. If the potential impact of radiative forcing (a multiplier of 2 was used) was to be included, the total CO_2 emissions of the cohort interviewed may be as high as 312 tonnes (8.3 tonnes per person), flying-related CO_2 emissions taking up 43% of the adjusted estimate.

In general, smaller houses were associated with lower CO_2 emissions than larger houses. Allowing for size, a general finding was that those living in single occupancy households have higher CO_2 emissions per person compared to those living in multiple occupancy households. Other factors which affected total energy consumption included boiler type (households employing combi-boiler associated with lower CO_2 emissions than those with conventional boiler) and building type (flats associated with lower CO_2 emissions than detached houses). Energy conservation within households competes with other goals such as comfort and luxury. As such, people in general, although agreeing in principle with the need to conserve energy, are poorly motivated to do so. Commonly cited reasons include a lack of guidance and governmental assistance. Another prominent finding was that within the cohort studied, awareness of energy consumption was lacking. This may, in part, be due to limited information provided by energy bills, and direct debit methods of payment. Another possible reason, especially amongst the doctors, could be the low cost of energy in proportion to the total household income.

More than half of the individuals interviewed commute to work by car. Car usage was very much dependent on the distance between home and work, as well as the availability and convenience of public transport. In general, individuals who lived within 2 km from the hospital walk to work, those who lived beyond 10 km from the hospital were dependent on cars to get to work. Those who lived between 2 and 10 km used a mixture of traveling methods i.e. walking, cycling, public transport, cars. Car sharing, although potentially the most effective way of reducing carbon emissions from car usage, was not adopted by those interviewed. In addition, car ownership was associated with frequent short trips (such as for groceries) which could otherwise be taken on foot. Taken together, such short trips could produce a significant amount of CO_2 emissions.

The doctors in the cohort interviewed flew much more than their paramedical counterparts. On average, doctors made 9.4 trips by air last year, vs 2.8 trips made by other healthcare professionals. CO_2 emissions from such flights, as calculated using the method proposed by DEFRA, amounted to 3.3 tonnes for doctors, and 1.3 tonnes for others. There also was a trend for more senior doctors (consultants and registrars) to fly more than their juniors. This was at least in part due to business related travel.

There was marked variation in carbon emissions amongst the individuals interviewed. Such variation hints towards potential for carbon emissions reduction. Indeed, when interviewed, most individuals acknowledged that more could be done to reduce personal carbon dioxide emissions. However, when asked about obstacles towards reducing CO_2 emissions, the commonest answers cited a lack of governmental support, with other common answers citing inconvenience and an unwillingness to sacrifice or adopt a lifestyle change. The majority of those interviewed felt that climate change was real and at least partly contributed to by human activity. Potential legislation for reduction of CO_2 emissions was discussed. Personal carbon trading appealed to most interviewees, followed by energy rationing. There was wide variation in what people thought was a fair tariff for a tonne of carbon dioxide emission. Personal carbon trading can be a useful policy framework that could improve "carbon literacy" of the general public that individuals can relate energy consumption to carbon usage.

This thesis has profiled the direct carbon dioxide emissions in a cohort of healthcare workers in a teaching hospital in the East Midlands by examining energy usage in 3 main spheres: household usage, car usage and flying. The study revealed a marked inter-individual variation in CO_2 emissions. The study also revealed low levels of awareness amongst individuals as to actual domestic energy usage, but a willingness amongst those interviewed to change behaviour in order to reduce CO_2 emissions. Potential methods for carbon dioxide emissions reduction were identified. The study employed a questionnaire method of data collection, which included a mixture of structured and open-ended questions. As with all methods of data collection, standardisation in terms of questions, algorithms, etc, would greatly benefit the questionnaire approach to calculating CO_2 emissions. This will become more relevant as the need to monitor energy usage becomes more pertinent as energy itself adopts a higher premium. Nonetheless, the questionnaire used in this study proved to be a robust and reproducible method of data collection, and a similar questionnaire could be utilized in further, more ambitious studies of carbon emissions.

Table 9.1.1 The combined individual CO_2 emissions from household energy use, car travel and flights

ID number	Profession	Household Type	Individual Household CO2 emissions (kg)	Individual car CO2 emissions (kg)	Individual flight CO2 emissions (kg)	Total individual CO2 emissions (kg)	*Flight CO2 emissions with RF impact (kg)*	*Individual CO2 emissions with RF impact (kg)*
O3	OT	Family	1,559	452	457	2,468	*914*	*2,925*
N10	Nurse	Family	1,087	0	1,735	2,822	*3,470*	*4,557*
D20	Reg	Couple	1,062	1,740	307	3,109	*614*	*3,416*
P1	PT	Couple	935	1,574	614	3,123	*1,228*	*3,737*
N4	Nurse	Couple	2,290	870		3,160		*3,160*
N2	Nurse	Family	1,161	1,690	372	3,223	*744*	*3,595*
D14	HO	Flat share	1,547	1,916	568	4,031	*1,137*	*4,599*
N7	Nurse	Family	1,738	0	2,459	4,196	*4,917*	*6,655*
D3	Reg	Family	1,289	1,740	1,421	4,450	*2,842*	*5,871*
N8	Nurse	Family	1,549	0	2,936	4,485	*5,871*	*7,420*
D16	Reg	Couple	1,289	417	3,010	4,717	*6,021*	*7,727*
P2	PT	Flat share	2,196	2,358	854	5,408	*1,707*	*6,261*
D1	SHO	Couple	2,175	1,740	1,599	5,513	*3,198*	*7,112*
D11	Reg	Flat share	2,122	3,479		5,601		*5,601*
O2	OT	Couple	1,547	3,160	966	5,673	*1,932*	*6,640*
N9	Nurse	Couple	1,161	3,213	1,426	5,799	*2,851*	*7,225*
N5	Nurse	Single	2,723	1,474	1,762	5,958	*3,523*	*7,719*
D13	Reg	Couple	3,607	1,928	504	6,039	*1,007*	*6,543*
N1	Nurse	Family	1,128	3,410	1,629	6,167	*3,258*	*7,796*
N3	Nurse	Single	6,452	0		6,452		*6,452*
N11	Nurse	Flat share	1,209	2,358	3,508	7,075	*7,017*	*10,584*
D18	Cons	Family	2,694	4,463		7,157		*7,157*
D10	SHO	Single	2,798	3,479	907	7,183	*1,813*	*8,090*
D12	HO	Flat share	1,934	1,768	3,916	7,619	*7,833*	*11,535*
D2	SHO	Couple	3,099	3,561	1,015	7,674	*2,029*	*8,689*
D9	Reg	Family	2,177	2,932	2,876	7,985	*5,752*	*10,861*
D6	Reg	Couple	2,050	6,201		8,251		*8,251*
D15	HO	Flat share	1,814	0	6,817	8,631	*13,634*	*15,448*
O1	OT	Couple	3,388	4,421	935	8,743	*1,869*	*9,677*
O4	OT	Couple	2,199	7,150		9,349		*9,349*
D5	Reg	Single	4,925	1,740	2,767	9,432	*5,534*	*12,199*
D17	Cons	Single	4,836	2,422	2,477	9,735	*4,954*	*12,212*
D4	HO	Single	2,771	2,087	4,905	9,764	*9,810*	*14,668*
N6	Nurse	Couple	2,944	4,687	2,166	9,796	*4,331*	*11,962*
D7	Reg	Single	2,657	1,740	5,577	9,974	*11,154*	*15,551*
D19	Cons	Single	8,061	1,740	1,466	11,266	*2,931*	*12,732*
D8	Cons	Single	2,405	5,724	4,833	12,962	*9,667*	*17,796*
Total			90,582	87,627	66,782	244,992	133,564	311,774
Average			2,448	2,368	2,154	6,621	4,309	8,426

Bibliography

Carbon Trust (2006), *The carbon emissions generated in all that we consume,* Carbon Trust, London

Davies, A.(2002), *Making travel plans work: Evidence form the NHS*, Department for Transport

DEFRA (2006), *Climate Change: The UK Programme 2006*, The Stationary Office, London

DEFRA (2007), *Act on CO_2 Calculator: Public Trial Version, Data, Methodology and Assumptions Paper*, Department of Environment, Food and Rural affair, London

DEFRA (2007), *Guidelines to Defra's GHG conversion factors for company reporting,* Department of Environment, Food and Rural affair, London

Dobson, A. (2003), *Citizenship and the Environment*, Oxford University Press, Oxford

Dresner, S & Ekins, P. (2004), *The Social impacts of Environmental Taxes: Removing Regressivity. Economic Instruments for a Socially Neutral National Home Energy Efficiency Program*, Research Discussion Paper 18, Policy Studies Institute, London

DTI (2003), *Our Energy Future – Creating a low carbon economy*, A White Paper on Energy, February 2003, Department of Trade and Industry, London

DTI (2004), *Energy consumption in the United Kingdom*, Department of Trade and Industry, London

DTI (2006), *The Energy Challenge, Energy Review Report 2006*, Department of Trade and Industry, London

DTI (2007), *Meeting the Energy Challenge*, A White Paper on Energy, May 2007, Department of Trade and Industry, London

DTI. (2007), *Quarter Energy Prices, June 2007*, A national statistics publication, Department of Trade and Industry, London

DTI (2007), *UK Energy in Brief in July 2007*, A National Statistics Publication, Department of Trade and Industry, London

DTI (2007), *Energy billing and metering – changing consumer behaviour*, August 2007, Department of Trade and Industry, London

Fleming, D. (2005), *Energy and Common purpose – Descending the energy staircase with Tradable Energy Quotas (TEQ)*, The Lean Economy Connection, London

FoE (2005), *Energy and Climate Change*, Friends of the Earth, London

Hillman, M. & Fawcett, T. (2004), *How we can save the planet*, Penguin Books, London

Houghton et al. (2001), "Climate Change 2001 – The Scientific Basics", Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge

IPCC (2007), *Climate Change 2007*, Impacts, Adaptation and Vulnerability Summary for Policymakers, Intergovernmental Panel on Climate Change, Geneva

Jardine, C. N (2005), *Part 1: Calculating the environmental impact of aviation emissions & Part 2: Making sense of the science " A review of climate care's approach to accounting for aviation emissions"*, Environmental Change Institute, Oxford University Centre for Environment, Oxford

Mayor of London. (2007), *Action today to protect tomorrow, The Mayor's Climate Change Action Plan,* Mayor of London, Greater London Authority City Hall, London

Meyer, A. (2000), *Contraction and Convergence,* The global solution to Climate Change, Green Books, Totnes

ONS (2007), *Social Trends, No 37 2007 edition,* Office for National Statistics, Available at http://www.statistics.gov.uk/downloads/theme_social/Social_Trends37/Social_Trends_37.pdf

ONS (2004), *The impact of UK households on the Environment through Direct and Indirect Generation of Greenhouse has emissions*, Office for National Statistics, London

Roberts, S. & Thumin, J. (2006), *A rough guide to Individual carbon trading, the ideas, the issues and the next steps*, Department of Environment, Food and Rural Affair, London

Shorrock, L. D., Henderson, J. , Utley, J.I. (2005), *Reducing carbon emissions from the UK Housing stock*, Housing Centre, BRE Environment, Watford

Smith, K. (2007), *The Carbon Neutral Myth Offset your indulgences for your climate sins*, Carbon Trade Watch, Amsterdam

Starkey, R. & Anderson, R. (2005), *Domestic Tradable Quotas, A policy instrument for reducing greenhouse gas emissions from energy use, Technical Report 39*, Tyndall Centre for Climate Change Research, Norwich

Stern, N. (2006), *The Economics of Climate Change, The Stern Review*, Cambridge University Press, Cambridge

Wiedmann, T. & Minx, J (2007), *A definition of carbon footprint*, ISA UK Research Report, Durham

Useful Websites

http://www.carbontrust.co.uk/default.ct: Website of Carbon Trust

http://www.defra.gov.uk/environment/climatechange/index.htm : Website of Department of Environment, Food and Rural Affairs (Information on Climate Change)

http://www.dti.gov.uk/index.html: Website of Department of Trade and Industry

http://www.energysavingtrust.org.uk: Website of Energy Saving Trust

http://www.ipcc.ch/ : Website of Intergovernmental Panel on Climate Change

http://www.royalsoc.ac.uk/landing.asp?id=1278 : Website of the Royal Society (Information on Climate Change)

http://www.rsacarbonlimited.org/default.aspa: Website of the Royal Society of Art (Carbon Limited Project)

http://www.statistics.gov.uk/: Website of National Statistics Online

Online CO_2 calculators

http://actonco2.direct.gov.uk/index.html: Website of Act on CO2 government calculator

http://www.carbonneutral.com: Website of The Carbon Neutral Company

http://www.climatecare.co.uk : Website of Climate Care

Appendix

Appendix A: Personal carbon footprint questionnaire

General Information
Q1. What is your gender? 1. Female 2. Male
Q2. How many people live in your house? |__|__| people
Q3. What is the age of each individual in your house? 1. Yourself: |__|__| years old 2. Person 2: |__|__| years old 3. Person 3: |__|__| years old 4. Person 4: |__|__| years old 5. Person 5: |__|__| years old 6. Person 6: |__|__| years old
Household Energy Consumption
Q4. What is your annual electricity consumption? Please answer in kWh or GBP. Annual electricity consumption |__|__|__|__|__| kWh or £ |__|__|__|
Q5. What is your annual gas consumption? Please answer in kWh or GBP. Annual gas consumption |__|__|__|__|__| kWh or £ |__|__|__|
Q6. Does any portion of your electricity come from renewable sources? 1. Yes 2. No **If "Yes", approximately what percentage of your total electricity comes from renewable sources?** (   ) %

Q7. Do you own or rent your property?

1. Owner
2. Tenant

Q8. When was your house built?

1. Pre 1919
2. 1919 to 1944
3. 1945 to 1964
4. 1965 to 1980
5. 1981 to 2001
6. Post 2001

Q9. What is your dwelling type?

1. End terrace
2. Mid terrace
3. Detached
4. Semi-detached
5. Flat
6. Maisonette

Q10. How many bed rooms does your house have? Please enter "0" for a studio.

|__|__|

Q11. Do you have any double glazing in your home?

1. None
2. Less than 10% of total glazing
3. 10 ~ 50% of total glazing
4. More than 50% of total glazing

Q12. Do you have draught stripping (proofing) throughout the home?

1. Yes
2. No

Q13. Please enter the number of the following appliances you have in your home.

- Fridge Freezer combined ( )
- Fridges ( )
- Freezers ( )
- Combined washer dryer ( )
- Washing machine ( )
- Tumble dryer ( )
- Electric hob ( )
- Electric oven/grill ( )
- Gas hob ( )
- Gas oven/grill ( )
- Dishwasher ( )

Q14. Please enter the approximate size (large/medium/small), age (years) and energy efficiency rating if known, of your fridge, freezer and fridge freezer combined.

- Fridge Freezer combined 1 ( ) |__|__| years old Rating ( )
- Fridge Freezer combined 2 ( ) |__|__| years old Rating ( )
- Fridge 1 ( ) |__|__| years old Rating ( )
- Fridge 2 ( ) |__|__| years old Rating ( )
- Freezer 1 ( ) |__|__| years old Rating ( )
- Freezer 2 ( ) |__|__| years old Rating ( )

LARGE

MEDIUM

SMALL

Q15. How many TVs do you own in your home? Please select the type and size.

No. of TVs in your home ( )

TV 1

Type

1. Standard
2. Plasma
3. LCD

Size

|__|__| inches

TV2

Type

1. Standard
2. Plasma
3. LCD

Size

|__|__| inches

TV3

Type

1. Standard
2. Plasma
3. LCD

Size

|__|__| inches

Q16. Do you use any energy saving light bulbs?

1. None
2. At least one
3. At least five

Q17. Do you own any air conditioners in your home?

1. Yes
2. No

Heating system

Q18 (a). What is your central heating system?

1. "Wet" central heating system with radiators
2. "Wet" under-floor heating system
3. Electric under-floor heating system
4. Electric storage heater
5. Hot air system
6. Other ( )

Q18 (b). How is this fired?

1. Oil
2. Gas
3. Electricity
4. Other ( )

Q19. Please select your boiler type and enter its approximate age.

Boiler type

1. Conventional boiler
2. Condensing boiler
3. Combi-boiler
4. Other (   )
5. Unknown

Approximate age

|__|__| years old

Q20. Do you have a hot water tank to store domestic hot water?

1. Yes
2. No

If "No", please go to Q24.

Q21. How thick is the insulation (approximately in mm) of the hot water tank?

1. |__|__|__|mm

2. Unknown

Q22. Do you have electric immersion heater in the hot water tank to boost hot water?

1. Yes
2. No
3. Unknown

Q23. Do you use economy 7 rated electricity to heat water?

1. Yes
2. No
3. Not applicable

Q24. Do you have solar panels to heat water?

1. Yes
2. No

Q25. Do you use any other types of renewable energy? Please explain.

Travel
Q26. How many cars do you own? |__|__|
Q27. Do you or does anybody in your home (e.g. family, flatmate) work from home? 1. Yes 2. No **If "Yes", approximately how many days a week, do you work from home?** ( ) days
Q28. How far do you live away from work? (km) |__|__|__| km
Q29. What is your main method of commuting? Please tick the appropriate boxes and enter the approximate commuting time (minutes) for a typical day (one way only). 1. Walk ☐ ( ) minutes 2. Cycle ☐ ( ) minutes 3. Bus ☐ ( ) minutes 4. Tram ☐ ( ) minutes 5. Train ☐ ( ) minutes 6. Car ☐ ( ) minutes 7. Other ☐ ( ), ( ) minutes
Q30. What are your annual mileage, model, fuel type and age of your car(s)? If you do not own the car, but often rent a car, please enter the estimate for annual mileage and write down the model and age of the car you normally hire. <u>Car 1</u> 1. Annual mileage ( ) 2. Model + Engine Size ( ) 3. Fuel type: Petrol / Diesel / L.P.G. 4. Age ( ) years old <u>Car 2</u> 1. Annual mileage ( ) 2. Model + Engine Size ( ) 3. Fuel type: Petrol / Diesel / L.P.G. 4. Age ( ) years old

Rental car

1. Annual mileage ( )
2. Model + Engine Size ( )
3. Age ( ) years old

Q31. Please enter the approximate number of train journeys you make per year for business and other purposes.

Business

From	To	Single/Return	No. of journeys
e.g. Nottingham	London	Return	10

Other

From	To	Single/Return	No. of journeys
e.g. Nottingham	Edinburgh	Return	1

Q32. Please enter the approximate number of long distance bus/coach return journeys you make per year for business and other purposes.

Business

From	To	Single/Return	No. of journeys
e.g. Nottingham	London	Return	10

Other

From	To	Single/Return	No. of journeys
e.g. Nottingham	Oxford	Return	5

Q33. Please list the number of flights you have made in the past year for business and other purposes.

Business

From	To	Single/Return	No. of flights
e.g. London Heathrow	Boston	Return	2

Other

From	To	Single/Return	No. of flights
e.g. East Midland	Paris	Return	1

Food

Q34. How many portions of meat do you eat in a week? One portion is considered as one meal.

(   ) portions

Q35. How many times a week do you use a car for your food shopping?

(   ) times /week

Q36. How far do you travel by car for your food shopping? (km)

(   ) km

Q37. How many times a week do you go for your food shopping by other means?

1. Foot ☐ (   ) times/ week
2. Cycle ☐ (   ) times/ week
3. Bus ☐ (   ) times/ week
4. Other ☐ (   ), (   ) times/ week

Q38. Does the country of origin of food produce matter to you?

1. Yes
2. No

If "Yes", please explain your reason.

Attitudes

Q39. Do you personally think the climate has changed recently?

1. Yes
2. No
3. Maybe

Q40. Do you personally think that the climate change was man made?

1. Yes
2. No
3. Maybe

Q41. Do you recycle?

1. Yes
2. No

If "Yes", which of the following do you consciously recycle? Please tick the appropriate boxes and enter the approximate percentage you recycle.

1. Glass bottles ☐ (   )%
2. Plastic bottles ☐ (   )%
3. Drink cartons ☐ (   )%
4. Plastic bags ☐ (   )%
5. Light bulbs ☐ (   )%
6. Cardboard boxes / Paper ☐ (   )%
7. None of the above ☐

Q42. Is there a community car sharing scheme in your neighbourhood?

1. Yes
2. No

If "Yes", do you participate in this scheme?

1. Yes
2. No

Q43. What do you think are the major obstacles to implement a car sharing scheme in your community?

Q44. Air travel is the most polluting form of travel. Should carbon tax be applied to flying?

1. Yes
2. No

Q45. Many companies are offering carbon offsetting projects such as planting trees in developing countries. Would you consider purchasing these products?

1. Yes
2. No

Q46. If you have you taken up any actions to reduce your CO2 emissions recently, please tick the appropriate boxes.

1. I installed solar panel or wind turbine or heat pump etc in my house. ☐
2. I changed my car to the fuel efficient car. ☐
3. I have upgraded my fridge/freezer/fridge freezer combined to the more energy efficient type. ☐
4. I have upgraded my boiler to the more energy efficient type (e.g. combi boiler). ☐
5. I have installed loft insulation/wall insulation/double glazing. ☐
6. I changed the light bulbs to energy efficient light bulbs. ☐
7. I now walk and cycle more. ☐
8. I reduced the number of flights I take. ☐
9. I don't leave the equipments (e.g. TV, computers, stereos etc) on stand by when I don't use. ☐
10. When I use a kettle, I only boil the water I need to use. ☐
11. I switch off lights when they are not in use. ☐
12. I buy groceries from local regions closer to the UK to reduce my food miles. ☐
13. Other. ( )

Q47. This questionnaire involved an exercise of reviewing your personal carbon footprint. Do you think more can be done to reduce your personal emissions?

1. Yes
2. No

If "Yes", what would you do to reduce your emissions?

Q48. Reducing the individual CO2 emissions can be challenging. Please tick the appropriate reasons that prevent you adopting a more environmentally friendly lifestyle and rank them in order of significance.

1. I don't believe in the climate change and I don't feel the need to reduce my emission. ☐
2. The damage has already been done and I don't see any point in taking any actions. ☐
3. I don't know how much emissions I am currently causing and I never had any urge to do something about it. ☐
4. I care about the environment, but I am not prepared to give up my current life style. ☐
5. There is a lack of support by the government to assist the general public to lead the more environmentally friendly life style. ☐
6. My lifestyle is low carbon intensive and I feel that I have already done my part. ☐
7. Other. ☐ ( )

Q49. Many people feel that the government should be doing more to reduce carbon emissions on a national level. If the government were to take a more active role, which of the following do you support?

1. Higher taxation on energy
2. Energy rationing (Enforced ceiling on personal carbon emissions)
3. Personal carbon trading* (See below)
4. None of the above. Please specify if you have any other ideas.

***Personal Carbon Trading**

Personal carbon trading – variously described as personal carbon allowances, domestic tradable quotas, and tradable energy quotas – is a potential way of reducing domestic greenhouse gas emissions. An overall emissions cap is set, and emissions rights are then divided equally across the population. These "carbon credits" are then surrendered upon the purchase of energy/fuel/transport. Those who need or want to emit more than their allowance will have to buy allowances from those who can emit less than their allowance. Over time, the overall emissions cap (and hence individual allocations) could be reduced in line with international or nationally adopted agreements.

Q50. What do you think would be the fair price for a tonne of CO2 emissions in the context of personal carbon trading? FYI – A tonne of CO2 is equivalent to a single flight from London to Mumbai per passenger. *(Source: www.climatecare.org)*

1. £5
2. £10
3. £20
4. £50
5. £100
6. £200
7. £500